

COMPUTER SIMULATION OF A COTTON PRODUCTION SYSTEM

Users Manual

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This publication reports work done under Regional Research Project S-69, "Engineering Systems for Cotton Production," a joint effort of the Agricultural Research Service, U.S. Department of Agriculture, and the State agricultural experiment stations of Alabama, Arizona, Arkansas, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas. The State experiment station research was supported in part by allotments from the Regional Research Fund established by the Hatch Act, as amended August 11, 1955, and administered by the Cooperative State Research Service, U.S. Department of Agriculture.

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PART 1.—SCOPE AND APPLICATION

By Rex F. Colwick and James W. Jones²

There has been considerable interest in computer simulation of productivity, energy flow, water use, and pollution in the many different ecosystems over the earth's surface. Much of this work has been stimulated by the International Biological Program (IBP) and is oriented toward better management of the earth's resources. We report here considerable progress, independent of IBP, toward the modeling and simulation of cotton production systems.

There are several justifications for computer simulation of a large system. First, computer models focus attention on areas where knowledge is lacking and assist in the planning and management of team research. Second, these models are useful experimental aids for studying hypotheses about system relationships, allowing better understanding of the numerous components of a system and thus reducing the cost of applied research. Ultimately, in showing the relationships among system components, computer models form a base for sound management decisions and alternatives.

Our work commenced with the organization of Regional Research Project S-69, "Engineering Systems for Cotton Production," in 1968. No one researcher can have a comprehensive understanding of the structure and operation of each component of a crop production system, and this project has provided coordination among a number of researchers in developing a cotton production simulation model. Since its inception, many experimentalists have joined the effort to build data bases for submodels, and many are also using parts of the system to study large ecosystems.

¹ Cooperative research of Agricultural Research Service and Mississippi Agricultural and Forestry Experiment Station.

² Research leader, Cotton Production Research, and agricultural engineer, Southern Region, Agricultural Research Service, U.S. Department of Agriculture, P.O. Box 5465, Mississippi State, Miss. 39762. Colwick is Coordinator of Regional Research Project S-69.

This publication describes four simulation models of subsystems in the cotton production system. These models, encompassing seedbed preparation through harvesting and ginning, were interfaced for the first computer simulation of any crop production system in October 1973.³ Our research group is close to completing some insect management models that will soon be added to the simulation.

The first model simulates the soil-moisture profile in the seed zone (MOIST). It is a description of the moisture flux based on the conservation of water in the top 6 inches of soil. Water evaporates from a visible moisture front as the water diffuses through a layer of dry soil and is partially replaced by capillary water that moves from a moist region to a dry region in response to a moisture gradient. This model provides the moisture input to the following model, EMERGE.

EMERGE describes the germination and emergence of the seed. It is controlled by soil-moisture tension, soil temperature at the seed depth, and the mechanical impedance of the surface soil. When the model has simulated 50% seedling emergence, the plant model, SIMCOT II, is initiated.

SIMCOT II is based on conservation principles that include a carbohydrate balance, a moisture balance, and a nitrogen balance for the plant. It requires daily inputs of solar radiation, maximum and minimum air temperatures, rainfall, pan evaporation, plant population, water-holding capacity of the soil, nitrogen application rates and dates of application, and plant growth factors related to carbohydrate, water, and nitrogen balances. Daily outputs from this model include plant weight, the number of fruit, and the age and location of each fruit on the plant.

³ Bowen, H. D., Colwick, R. F., and Batchelder, D. G. 1973. Computer simulation of crop production: Potential and hazards. *Agric. Eng.* 54 (10): 42-45.

Boll opening rate curves from this model can be used to initiate the harvesting process described in the last model, HARVSIM.

HARVSIM is a single-farm harvesting model that simulates passes made in the fields by the harvesters, the selection of trailers for filling, the transporting of trailers to the gin and of empty trailers to the farm, and gin backlog. An option includes twice-over harvesting in which the second harvesting of a given field occurs only if the remaining cotton would yield more than a specified amount. The model takes the cotton on through the ginning process and is capable of assigning economic values to the end product.

These models are in various stages of validation.

MOIST was verified for only one soil type and at one location primarily because the soil parameters necessary for additional verification are lacking; however, soil parameters are being developed for approximately 20 soils that represent about 80% of the cotton farmland in the United States. Some of these data should be available in 1975.

EMERGE was tested in five States for 2 or more years and produced satisfactory to excellent simulations in years in which the temperature increased progressively as the season advanced. Subsequently, a slight modification improved the simulation when a long cold period followed a warm period 2 or 3 days after planting. This modification needs more testing under various field and weather conditions.

SIMCOT II was tested at several locations, and when detailed mappings of the plant structure had been recorded twice a week and the environment had been monitored accurately, there was good correspondence between observed and simulated plant development, fruiting characteristics, and yield. More testing is needed particularly in the area of water stress, and more development is needed to apply this model to a field growth situation.

HARVSIM was tested for 2 years in the High Plains of Texas. Data for the first year show an excellent correspondence between simulation and observation. Second-year data have not been analyzed.

Although these models are in various stages of development and verification, this users manual is presented to document progress to date

and to offer these models to scientists as a tool which they may use to focus attention on aspects of the system where understanding is limited. This should help them identify missing links and assign research priorities.

These models are not sufficiently developed and tested to assist cotton producers with management decisions. Such use could result in economic losses. The full management capabilities of crop simulation will not be achieved until all major crops have been modeled. Furthermore, a number of submodels dealing with insects, diseases, root development, nutrients, and water relationships will be essential for producer decisions. These are under development.

To interface crop production submodels easily, it is possible to make simplifying assumptions based on the objective of the interface. This approach was successfully used to interface the four models described herein. In figure 1-1 crop management is shown as it relates to the cotton production system. Options were designed for running any combination of the models when the user specified appropriate inputs. For example, SIMCOT II could be run alone or with EMERGE and MOIST, or MOIST could be run alone. The integrated models were run to test hypothetical situations such as a 10-day cold spell following planting, which resulted in a realistic delay in maturity and a decrease in yield.

A simulation of planting through harvesting provided very interesting results. However, the assumptions that were made will probably not be sufficient for all applications of the model. For example, MOIST and EMERGE were interfaced to provide soil-moisture values. It was assumed that (1) the seed and seedling do not alter the soil-moisture-flux equations, (2) the soil temperature can be predicted from air temperature, (3) the relative humidity can be predicted from maximum and minimum air temperatures, the dew point temperature of the previous day, and rainfall, and (4) physical impedance is known. MOIST provided a table of the hourly moisture contents at planting depth; however, EMERGE required moisture tension values in bars as input. To use the interfaced models, a soil moisture-soil tension relationship and a moisture release equation are needed for the soil being tested.

These equations are being developed for 20 soils, as mentioned above, at North Carolina

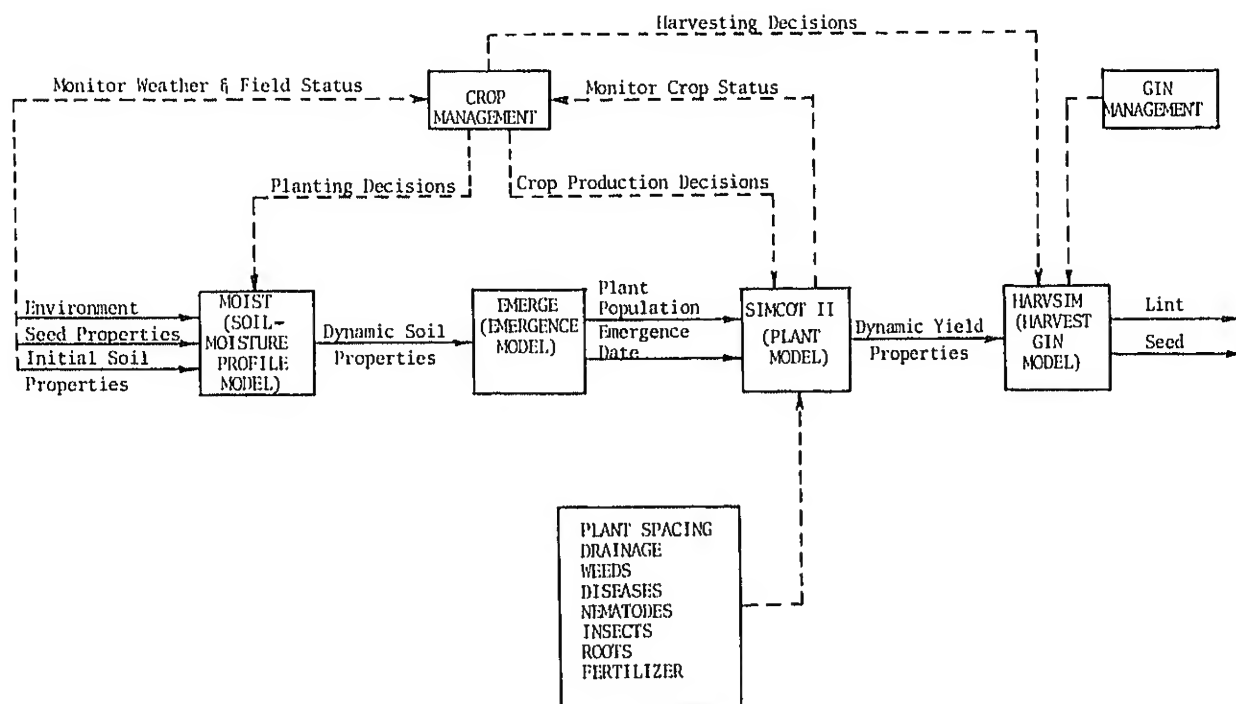


FIGURE 1-1.—Schematic of initial interface of MOIST, EMERGE, SIMCOT II, and HARVSIM.

State University. Also, Henry D. Bowen and others at North Carolina State University are attempting to obtain enough data so that EMERGE can be used without having to measure moisture, temperature, and physical impedance daily. This technique will be based on soil types and will be developed from National Weather Service information and the reaction of the soil to initializing inputs of moisture, temperature, and physical impedance.

SIMCOT II was initiated when MOIST-EMERGE predicted 50% emergence. It was assumed that from this point carbohydrate production and assimilation would be the controlling factor in plant development. A major assumption was that a single plant can be used to make predictions of growth and yield; the variability among plants, their competition, and environmental variability were not considered. Again, depending on the objective, this may or may not be suitable. Also, no insect models were integrated into this initial effort.

SIMCOT II predicted the boll opening rate used as input to HARVSIM. For this interface it was assumed that (1) no preharvest chemical aids had been used and that (2) nothing happened to the plant except the removal of open

bolts. Both assumptions were based on considerable past research, but for some applications they may be unacceptable.

Considerable work remains to be done to interface these and other models at the field level. In many cases, detailed models of interactions of various physical and biological systems will be just as complicated as any of the independent models. For example, interfacing an insect population dynamics model with a crop model might be accomplished by modeling the behavior and metabolism of the insects as influenced by weather, crop factors, and insect preferences. Such an interface would allow detailed studies of the interactions and provide needed assumptions and relationships for higher level models.

An ultimate goal of these models, as mentioned earlier, is to optimize crop production systems. In addition, they will provide information for farm management decision models. Optimization models require a statement of what is to be optimized. At the producer (farm) level, profits are generally optimized (maximized) subject to the constraints particular to a given farm. However, researchers may study an optimization model designed to maximize yield or minimize production cost at the crop model level.

PART 2.—MOIST: A SIMULATION OF THE MOISTURE PROFILE OF A BARE SOIL AFTER PLANTING

By Charlie G. Coble,¹ Henry D. Bowen,² and Henry L. King, Jr.,³

DESCRIPTION

MOIST is a computerized mathematical model for predicting soil water profiles during the drying of soil. It accounts for water movement in the soil in both the liquid and the vapor states and the evaporation of water to the atmosphere.

Liquid water movement is computed with the soil water diffusivity equation:

$$J_c = -D(\theta) \frac{d\theta}{dx},$$

where J_c = flux of water in grams per second per square centimeter,

(θ) = soil water diffusivity in square centimeters per second,

$D(\theta)$ = water content in cubic centimeters per cubic centimeter of soil,

and $\frac{d\theta}{dx}$ = gradient of water content in cubic centimeters per cubic centimeter of soil per centimeter of distance.

The transfer of water in the vapor state because of temperature gradients is calculated with the equation

$$J_v = -D \frac{dC}{dx} - L_{ve} \frac{d(\ln T)}{dx},$$

where J_v = flux of water vapor in grams per second square centimeter,

D = diffusion coefficient of water vapor in soil matrix in square centimeters per second,

C = concentration of water vapor in soil air or atmospheric air in grams per cubic centimeter of air,

$\frac{dC}{dx}$ = gradient of concentration of water vapor in soil air and in atmosphere in grams per cubic centimeter, per centimeter of distance,

L_{ve} = coupling coefficient between water vapor and heat energy in moles per second square centimeter,

T = temperature in degrees Kelvin,

and x = distance over which diffusion is occurring in centimeters.

The water evaporated to the atmosphere is controlled by vapor diffusion through the dry overlying soil layer and is calculated with the equation

$$J_e = -D \frac{dC}{dx},$$

where J_e = evaporation flux as water vapor diffusing through soil from visible moisture front to soil surface in grams per second square centimeter,

D = diffusion coefficient for water vapor through soil matrix in square centimeters per second,

and $\frac{dC}{dx}$ = concentration gradient of moisture in soil air from visible moisture front to soil surface in grams per cubic centimeter per centimeter of distance.

Inputs to the simulation are weather and soil data (air temperature, atmospheric relative humidity, soil temperature, water vapor diffusion coefficients in soil, soil water diffusivities,

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soil bulk density, and energy-mass coupling coefficients).

The model was verified for use on Ruston loamy sand soil and is adaptable to other soils. It can be used to accurately assess the effect of cultural practices on the soil water content profiles in drying soil. It was used to examine the effects of bulk density, wind, liquid water conductivity

barriers, and surface films on the soil water content profiles under drying conditions.

The costs of using the model to optimize a cultural practice, including the cost of empirical verification of results, are estimated to be 0.01 to 0.1 of those required for obtaining the same information by empirical methods alone.

LIMITATIONS

The major limitation of MOIST is the large number of temperatures and relative humidities required for the program. For instance, with 15 soil layers, air temperature, and relative humidity, there are 408 items per day of input. Just obtaining the data is a major operation, and then it must be punched in. However, for in-depth studies of moisture movement in the top inch of soil, these data are required. A second limitation is that the soil parameters necessary for the program are available only for a Ruston loamy sand soil.

The thermal vapor section of the program is not very important in humid regions except possibly in the surface inch or less of soil and for high-radiation conditions. For large-seed crops, such as cotton, corn, soybeans, and peanuts, this section can probably be bypassed without serious

error, but it will probably be necessary for small-seed crops planted at shallow depths. Where the vapor transfer can be bypassed, it is not necessary to have temperature inputs for all layers, but only for the visible drying front, for which air and soil temperatures are required. If the thermal vapor transfer is bypassed, the mass-energy coupling coefficient also need not be obtained. By using a constant temperature throughout the soil profile, the thermal gradient is bypassed. This is usually some function of air temperature, such as TA-3. However, it is desirable that the temperature at the visible moisture front be estimated as closely as possible for accurate operation. Tests are in progress to develop estimates of temperature at the visible moisture front from air temperature, wind, a roughness coefficient, and solar radiation.

DEFINITION OF TERMS

ADC	Diffusion coefficient for the layer approximately halfway between the evaporation front and the surface to make sure it is diffusing through the dry soil.	GRADLT	Gradient of the log of the temperature.
AGRAD	Water vapor driving gradient from moisture front to the surface.	IP	The number of 1-cm layers in which the soil profile is divided.
AIST	Distance from middle of Kth layer to the surface in centimeters when 1-cm-thick layers are used.	IT	The total number of time periods for the model to run.
BD	Array for the bulk density of each soil layer.	L	The first L in MOIST is $k/2$; it is used to select a dry layer that is over the evaporation front. The second L is a DO loop subscript.
CATM	Water vapor concentration of atmosphere in grams per cubic centimeter of air.	QCOND	Array of the amount of water transferred out of each soil layer in the form of liquid water.
CCOEF	Energy-mass coupling coefficient.	QCOND D	Array for each soil layer of the liquid water transferred down.
COUPL	Array of the part of thermal vapor transfer due to the energy-mass coupling for each soil layer.	QCONDU	Array for each soil layer of the liquid water transferred up.
DCONST	Array of water vapor diffusion coefficient in soil for each soil layer. Computed in real function routine listed at end of program.	QEVAP	Array of the quantity of evaporated moisture.
EVAPJ	Evaporation flux in grams per second.	QVAPOR	Water vapor transfer due to temperature gradient per soil layer (array).
FICKS	Array of the part of thermal vapor transfer due to Fick's law for each soil layer.	RH	The relative humidity of the atmospheric air during the time period.
FVAPOR	Water flux in grams per second due to temperature gradient.	SAVE	Evaporation from moisture front.
GRADC	Water vapor concentration of atmosphere in grams per cubic centimeter of air per centimeter of distance.	SAVE1	Distance in centimeters from the surface of the soil to the moisture front of the soil.
		SEC	The number of seconds in each time period.

SWITCH	Allow moisture to evaporate from the layer with moisture front in it.		soil layer in cubic centimeters of water per cubic centimeter of soil.
T	Array for the temperature of each soil layer during the time period.	WATER	Array of moisture level of each soil layer in grams of water per cubic centimeter of soil.
TA	The temperature of the atmosphere air during the time period.	WC	Array for water content of each soil layer (dry-weight basis). Example: 6%, read in as 0.06.
TCK	Array of temperature converted to Kelvin for each soil layer.	WDIFF	Diffusivity coefficient for a particular soil.
VWC	Array of volumetric water content for each		

INPUT/OUTPUT

Input

Program inputs read in as data are arranged in the following order and formats:

1. IP, IT, and SEC on one card in I10, I10, and F10.0 format.
2. BD array (bulk density of each soil layer) arranged in 15F5.0 format.
3. WC array (initial moisture content at each soil layer) arranged also in 15F5.0 format.
4. RH, TA, and T (RH and TA are single variables and T is an array) arranged in F3.0, F2.0, and 15F5.0 format.

The maximum number of soil layers is 15. If a deeper profile is needed, enlarge the dimension statement and the input and output formats.

Output

The output of the program consists of the time period, the moisture content of each level for that time period, the distance from the surface to the center of the soil layer with the moisture front, and the quantity of evaporated moisture. The output variables are J, (WC(I), I=1, IP), SAVE1, and SAVE, formatted as 15, 15F7.4, F5.2, and E15.6.

PROGRAM SETUP AND EXECUTION

MOIST is written in FORTRAN G, a standardized FORTRAN supported by IBM, for the IBM 370/165 computer. The program does not use any special system functions, but is easily transformable to any FORTRAN compiler. The standard code for an IBM 370/165 is EBCDIC, and the cards were punched on an IBM 029 key-punch.

The card deck is arranged in the following sequence:

- A. Control cards
 1. Job card
 2. // EXEC FTGCLG
 3. //C.SYSIN DD *
- B. Main program deck
- C. Function
- D. Control cards
 1. /*
 2. //G.SYSIN DD *

- E. Data
- F. Control cards
 1. /*
 2. //

The // EXEC FTGCLG card in the control section tells the computer to compile, link and execute the program. The //C.SYSIN DD * card causes the program and the function to be compiled. All initializing of values to zero should be done in the program. All linkage to execute a FORTRAN program is then compiled. The //G.SYSIN DD * card then causes the program to be executed using the following data cards. The compiled program uses approximately 5,000 memory locations, and the execution requires 30,000 memory locations on the IBM 370/165. To simulate 4 days, the computer compile and execution times are approximately 2.0 and 5.0 seconds, respectively.

PROGRAM LISTING

```

C   THIS PROGRAM CALCULATES DISTRIBUTION OF MOISTURE DURING THE
C   DRYING STAGE
      DIMENSION BD(15), WC(15), T(16), C(16), WATER(15), QEVAP(15),
      IQVAPOR(16), QCOND(16), DCONST(15), QCONDU(16), QCONDD(15), VWC(15),
      IFICKS(15), COUPL(15), TCK(16)
      READ(1,51) IP, IT, SEC
      READ(1,52) (BD(I), I=1, IP)
      READ(1,53) (WC(I), I=1, IP)
51  FORMAT(2I10, F10.0)
52  FORMAT(15F5.0)
54  FORMAT(F3.0, F2.0, 15F5.0)
53  FORMAT(15F5.0)
27  FORMAT(' TIME   WC(1)  WC(2)  WC(3)  WC(4)  WC(5)  WC(6)  WC(7)  WC
      1(8)  WC(9)  WC(10)  WC(11)  WC(12)  WC(13)  WC(14)  WC(15)  DIST  QEVAP')
      WRITE(3,27)
      DO 125 M=1, IP
125  VWC(M) = WC(M) * BD(M)
      DO 75 J=1, IT
      READ(1,54) RH, TA, (T(I), I=1, IP)
      T(16) = T(15)
      DO 75 J2=1, 4
      SWITCH=0
      DO 1 K=1, 16
1  C(K) = 2.288E-6 * 10**((T(K)-3)/76)
C   MOISTURE TRANSFER DUE TO TEMPERATURE GRADIENTS SECTION
      DO 90 K=1, IP
      DCONST(K) = D(T(K), BD(K), WC(K))
C   THIS STATEMENT SKIPS MOISTURE TRANSFER IF MOISTURE CONTENT IS
C   LESS THAN 1%.
      IF(WC(K).LE.0.018) GO TO 105
      CCOEF = (-0.0000067 + 0.000384*WC(K))/ 18
      GRADC = C(K) - C(K+1)
      TCK(K) = 5*(T(K)-32)/9+273
      TCK(K+1) = 5*(T(K+1)-32)/9+273
      GRADLT = ALOG(TCK(K)/TCK(K+1))
      FICKS(K) = DCONST(K)*GRADC
      COUPL(K) = CCOEF*GRADLT
      FVAPOR = FICKS(K) + COUPL(K)
      QVAPOR(K) = FVAPOR * SEC
      QVAPOR(K) = ABS(QVAPOR(K))
      GO TO 110
105  QVAPOR(K) = 0
110  CONTINUE
C   EVAPORATION SECTION
C   THIS STATEMENT BYPASSES EVAPORATION STEP IF MOISTURE CONTENT
C   IS LESS THAN 0.5%
      IF(WC(K).LE.0.005) GO TO 80
C   THIS STATEMENT BYPASSES EVAPORATION STEP IF EVAPORATION HAS BEEN
C   CALCULATED FOR A HIGHER SLICE
      IF(SWITCH.EQ.1) GO TO 80
      CATM = 2.288E-6 * 10**((TA-3)/76)*RH
      DIST = K - 0.5
      SAVE1 = DIST
      AGRAD = (C(K) - CATM)/ DIST
      L = K/2
      IF(L.LE.1) L = 1
      ADC = DCONST(L)
      EVAPJ = ADC*AGRAD
      QEVAP(K) = EVAPJ * SEC
      QEVAP(K) = ABS(QEVAP(K))
      SAVE = QEVAP(K)
      SWITCH = 1

```

PROGRAM LISTING—Continued

```

      GO TO 70
80  QEVAP(K) = 0
      L=0
      DIST=0
      AGRAD=0
      ADC=0
      EVAPJ=0
C    THIS SECTION COMPUTES WATER TRANSFERRED DUE TO HYDRAULIC CONDUCTIVITY
70  IF(VWC(K).LE.0.02) GO TO 480
      IF(VWC(K).LE.0.055) GO TO 135
      WDIFF=(10**((VWC(K) - 0.046) / 0.036))* 0.00001
      GO TO 91
135  WDIFF = 1.55E-5
      GO TO 91
480  WDIFF=0.0
      91 IF(K.EQ. 1) GO TO 11
          IF(WC(K) - WC(K-1)) 11,11,12
12  QCONDU(K) = WDIFF * (VWC(K) - VWC(K-1)) * SEC
      GO TO 15
11  QCONDU(K) = 0
15  IF(K.EQ.15) GO TO 13
      IF(WC(K) - WC(K+1)) 13,13,14
14  QCONDD(K) = WDIFF * (VWC(K) - VWC(K+1)) * SEC
      GO TO 16
13  QCONDD(K) = 0
16  QCONDU(16)=0
      90 CONTINUE
430  DO 18 N=1,15
          IF(N .EQ. 1) GO TO 17
          QCOND(N) = -QCONDD(N) - QCONDU(N) + QCONDU(N+1) + QCONDD(N-1)
          GO TO 18
17  QCOND(N) = - QCONDD(N) + QCONDU(N+1)
18  CONTINUE
      DO 65 L=1,15
          WATER(L) = WC(L)*BD(L)
          IF(T(L) - T(L+1))45,40,40
40  IF(L.EQ.1) GO TO 100
          WATER(L) = WATER(L) - QEVAP(L) - QVAPOR(L) + QCOND(L) + QVAPOR(L-1)
          GO TO 50
100  WATER(L) = WATER(L) - QEVAP(L) - QVAPOR(L) + QCOND(L)
      GO TO 50
45  WATER(L) = WATER(L) - QEVAP(L) + QCOND(L) - QVAPOR(L)
      1+ QVAPOR(L+1)
50  IF(WATER(L).LE.0) WATER(L) = 0
      WC(L) = WATER(L)/BD(L)
      VWC(L) = WATER(L)
65  CONTINUE
      .WC(15) = WC(14) + WC(14) - WC(13)
75  WRITE(3,26) J, WC(1), WC(2), WC(3), WC(4), WC(5), WC(6), WC(7),
      1WC(8), WC(9), WC(10), WC(11), WC(12), WC(13), WC(14), WC(15),
      1SAVE1,SAVE
26  FORMAT(I5,15F7.4,F5.2,E15.6)
      RETURN
      END
      REAL FUNCTION D(T, BD, WC)
      TK =T+460
      E=0.286*((TK/492)**1.75)
      F=BD/2.65 + (WC*BD)
      F1=1.0-F-0.23
      D=E*F1
      RETURN
      END

```

EXAMPLE RUN

Input Data

For read statement	Field 1	Field 2	Field 3	Field 4	Field 5	...	Field 14	Field 15	Field 16	Field 17
Read(1,51) IP,IT,SEC	15	79	900	1.08	1.08	...	1.3	1.3		
Read(1,52) (BD(I),I=1,IP)	1.08	1.08	1.08	0.0703	0.0703	...	0.0703	0.0703		
Read(1,53) (WC(I),I=1,IP)	0.0703	0.0703	0.0703	T(1)	T(3)	...	T(12)	T(13)	T(14)	T(15)
	RH	TA	58	58	58	...	60	61	61	61
Read(1,54) RH,TA,(T(I),I=1,IP)	0.28	74	61	60	60	...	60	61	62	63
	0.28	73	68	68	67	...	64	64	64	65
	0.22	81				...				

Output Data

TIME	WC(1)	WC(2)	WC(3)	WC(4)	WC(5)	WC(6)	WC(7)	WC(8)	WC(9)	WC(10)	WC(11)	WC(12)	WC(13)	WC(14)	WC(15)	DIST	QEVAP
1	0.0693	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.50	0.106599E-02
1	0.0684	0.0702	0.0703	0.0702	0.0712	0.0696	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.50	0.106996E-02
1	0.0675	0.0701	0.0703	0.0703	0.0720	0.0690	0.0702	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.50	0.107370E-02
1	0.0667	0.0700	0.0703	0.0704	0.0727	0.0686	0.0700	0.0702	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.50	0.107724E-02
2	0.0656	0.0698	0.0703	0.0705	0.0732	0.0682	0.0698	0.0702	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.50	0.130920E-02
2	0.0646	0.0696	0.0703	0.0707	0.0737	0.0679	0.0696	0.0702	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0702	0.50	0.131430E-02
2	0.0637	0.0694	0.0702	0.0709	0.0741	0.0676	0.0694	0.0701	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0702	0.50	0.131917E-02
2	0.0627	0.0692	0.0702	0.0711	0.0744	0.0674	0.0692	0.0701	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0702	0.50	0.132385E-02
3	0.0613	0.0688	0.0702	0.0713	0.0748	0.0672	0.0691	0.0700	0.0702	0.0703	0.0703	0.0703	0.0703	0.0703	0.0702	0.50	0.189652E-02
3	0.0600	0.0685	0.0702	0.0715	0.0751	0.0671	0.0690	0.0699	0.0702	0.0703	0.0703	0.0703	0.0703	0.0702	0.0702	0.50	0.190620E-02
3	0.0587	0.0681	0.0702	0.0717	0.0753	0.0669	0.0688	0.0698	0.0702	0.0703	0.0703	0.0703	0.0703	0.0702	0.0701	0.50	0.191559E-02
3	0.0574	0.0677	0.0702	0.0718	0.0755	0.0668	0.0687	0.0697	0.0701	0.0702	0.0702	0.0703	0.0703	0.0702	0.0701	0.50	0.192475E-02
4	0.0554	0.0673	0.0701	0.0721	0.0757	0.0667	0.0686	0.0696	0.0701	0.0702	0.0702	0.0703	0.0702	0.0702	0.0702	0.50	0.252650E-02
4	0.0535	0.0670	0.0700	0.0723	0.0759	0.0667	0.0685	0.0695	0.0701	0.0702	0.0702	0.0703	0.0702	0.0702	0.0702	0.50	0.254434E-02
4	0.0516	0.0665	0.0699	0.0724	0.0760	0.0666	0.0684	0.0694	0.0700	0.0702	0.0702	0.0702	0.0702	0.0702	0.0702	0.50	0.256170E-02
4	0.0498	0.0661	0.0699	0.0726	0.0762	0.0665	0.0683	0.0693	0.0700	0.0702	0.0702	0.0702	0.0702	0.0702	0.0703	0.50	0.257868E-02
5	0.0472	0.0655	0.0698	0.0728	0.0763	0.0665	0.0682	0.0692	0.0699	0.0701	0.0701	0.0702	0.0702	0.0702	0.0703	0.50	0.351497E-02
5	0.0447	0.0649	0.0697	0.0730	0.0764	0.0664	0.0682	0.0692	0.0699	0.0701	0.0702	0.0702	0.0702	0.0702	0.0703	0.50	0.354667E-02
5	0.0421	0.0643	0.0696	0.0731	0.0765	0.0663	0.0681	0.0691	0.0698	0.0700	0.0701	0.0702	0.0702	0.0703	0.0702	0.50	0.357800E-02
5	0.0396	0.0636	0.0695	0.0732	0.0766	0.0663	0.0678	0.0689	0.0696	0.0700	0.0701	0.0702	0.0702	0.0703	0.0702	0.50	0.360910E-02
6	0.0363	0.0630	0.0694	0.0733	0.0768	0.0662	0.0679	0.0690	0.0697	0.0700	0.0702	0.0702	0.0702	0.0702	0.0702	0.50	0.448423E-02
6	0.0330	0.0623	0.0693	0.0733	0.0769	0.0662	0.0679	0.0690	0.0696	0.0700	0.0702	0.0702	0.0702	0.0702	0.0702	0.50	0.453430E-02
6	0.0297	0.0616	0.0691	0.0734	0.0770	0.0662	0.0678	0.0689	0.0696	0.0700	0.0702	0.0702	0.0702	0.0702	0.0701	0.50	0.458422E-02
7	0.0264	0.0609	0.0690	0.0734	0.0771	0.0661	0.0678	0.0688	0.0695	0.0699	0.0701	0.0702	0.0702	0.0702	0.0701	0.50	0.463413E-02
7	0.0221	0.0603	0.0688	0.0735	0.0771	0.0662	0.0677	0.0687	0.0694	0.0699	0.0701	0.0701	0.0701	0.0702	0.0701	0.50	0.569379E-02
7	0.0177	0.0596	0.0687	0.0735	0.0771	0.0662	0.0677	0.0687	0.0694	0.0699	0.0701	0.0701	0.0701	0.0702	0.0700	0.50	0.577410E-02
7	0.0135	0.0587	0.0685	0.0735	0.0772	0.0662	0.0676	0.0686	0.0694	0.0698	0.0701	0.0701	0.0701	0.0702	0.0700	0.50	0.585458E-02
7	0.0092	0.0579	0.0683	0.0735	0.0772	0.0662	0.0676	0.0686	0.0694	0.0698	0.0700	0.0701	0.0701	0.0701	0.0700	0.50	0.593185E-02
8	0.0040	0.0570	0.0681	0.0735	0.0772	0.0661	0.0676	0.0686	0.0693	0.0697	0.0700	0.0701	0.0701	0.0701	0.0700	0.50	0.704744E-02
8	0.0000	0.0536	0.0678	0.0735	0.0773	0.0661	0.0676	0.0686	0.0692	0.0696	0.0700	0.0701	0.0701	0.0701	0.0699	0.50	0.713343E-02
8	0.0010	0.0510	0.0672	0.0734	0.0773	0.0661	0.0676	0.0686	0.0692	0.0696	0.0700	0.0701	0.0701	0.0701	0.0699	0.50	0.722132E-02
9	0.0018	0.0485	0.0668	0.0733	0.0772	0.0662	0.0675	0.0685	0.0691	0.0696	0.0699	0.0701	0.0701	0.0701	0.0700	0.50	0.241768E-02
9	0.0025	0.0463	0.0663	0.0733	0.0772	0.0662	0.0675	0.0684	0.0691	0.0696	0.0699	0.0701	0.0701	0.0701	0.0700	0.50	0.241296E-02
9	0.0037	0.0422	0.0654	0.0730	0.0771	0.0663	0.0674	0.0684	0.0690	0.0696	0.0699	0.0701	0.0701	0.0701	0.0700	0.50	0.240853E-02
10	0.0042	0.0401	0.0649	0.0729	0.0771	0.0662	0.0674	0.0683	0.0690	0.0696	0.0699	0.0701	0.0701	0.0701	0.0700	0.50	0.244928E-02
10	0.0047	0.0382	0.0644	0.0727	0.0771	0.0662	0.0674	0.0683	0.0689	0.0696	0.0699	0.0701	0.0701	0.0701	0.0700	0.50	0.244532E-02
10	0.0052	0.0363	0.0638	0.0726	0.0771	0.0661	0.0674	0.0683	0.0689	0.0696	0.0699	0.0701	0.0701	0.0701	0.0700	0.50	0.244162E-02
10	0.0000	0.0368	0.0633	0.0724	0.0771	0.0661	0.0673	0.0682	0.0689	0.0695	0.0698	0.0701	0.0701	0.0701	0.0700	0.50	0.784429E-02
11	0.0005	0.0353	0.0629	0.0723	0.0770	0.0660	0.0673	0.0683	0.0688	0.0695	0.0698	0.0701	0.0701	0.0701	0.0701	0.50	0.202971E-02
11	0.0010	0.0338	0.0625	0.0721	0.0769	0.0659	0.0672	0.0683	0.0688	0.0694	0.0697	0.0700	0.0701	0.0701	0.0701	0.50	0.202660E-02
11	0.0015	0.0324	0.0621	0.0719	0.0769	0.0659	0.0672	0.0683	0.0688	0.0694	0.0697	0.0700	0.0701	0.0701	0.0701	0.50	0.202367E-02
11	0.0019	0.0311	0.0616	0.0717	0.0768	0.0658	0.0671	0.0683	0.0688	0.0693	0.0697	0.0700	0.0701	0.0701	0.0701	0.50	0.202090E-02
12	0.0023	0.0302	0.0612	0.0715	0.0765	0.0658	0.0671	0.0682	0.0688	0.0693	0.0697	0.0700	0.0701	0.0701	0.0701	0.50	0.163955E-02
12	0.0027	0.0293	0.0608	0.0713	0.0763	0.0658	0.0670	0.0681	0.0688	0.0693	0.0697	0.0700	0.0701	0.0701	0.0701	0.50	0.163755E-02
12	0.0031	0.0284	0.0604	0.0711	0.0761	0.0658	0.0670	0.0681	0.0688	0.0693	0.0697	0.0700	0.0701	0.0701	0.0701	0.50	0.163382E-02
12	0.0034	0.0275	0.0601	0.0709	0.0759	0.0658	0.0670	0.0680	0.0687	0.0692	0.0696	0.0700	0.0701	0.0701	0.0701	0.50	0.138995E-02
13	0.0037	0.0269	0.0597	0.0706	0.0758	0.0657	0.0669	0.0680	0.0687	0.0692	0.0695	0.0699	0.0701	0.0701	0.0701	0.50	0.138854E-02
13	0.0041	0.0262	0.0594	0.0704	0.0756	0.0657	0.0669	0.0680	0.0686	0.0692	0.0695	0.0699	0.0701	0.0701	0.0701	0.50	0.138719E-02
13	0.0044	0.0256	0.0590	0.0702	0.0755	0.0656	0.0669	0.0680	0.0686	0.0692	0.0695	0.0699	0.0701	0.0701	0.0701	0.50	

13	0.0047	0.0249	0.0587	0.0700	0.0753	0.0656	0.0668	0.0679	0.0686	0.0692	0.0695	0.0698	0.0701	0.0703	0.0704	0.138590E-02
14	0.0050	0.0245	0.0584	0.0698	0.0752	0.0654	0.0669	0.0679	0.0686	0.0691	0.0695	0.0698	0.0701	0.0703	0.0705	0.114205E-02
14	0.0052	0.0241	0.0581	0.0697	0.0750	0.0653	0.0668	0.0678	0.0686	0.0691	0.0695	0.0698	0.0701	0.0703	0.0705	0.114107E-02
14	0.0025	0.0247	0.0578	0.0695	0.0749	0.0652	0.0668	0.0678	0.0685	0.0690	0.0695	0.0698	0.0701	0.0703	0.0705	0.328325E-02
14	0.0028	0.0242	0.0576	0.0693	0.0747	0.0651	0.0668	0.0678	0.0685	0.0690	0.0695	0.0698	0.0701	0.0704	0.0706	0.114971E-02
15	0.0031	0.0238	0.0574	0.0692	0.0746	0.0651	0.0667	0.0678	0.0685	0.0690	0.0694	0.0698	0.0701	0.0703	0.0706	0.100465E-02
15	0.0033	0.0234	0.0571	0.0690	0.0744	0.0650	0.0666	0.0677	0.0684	0.0690	0.0694	0.0698	0.0701	0.0703	0.0706	0.100374E-02
15	0.0036	0.0231	0.0569	0.0688	0.0743	0.0650	0.0666	0.0677	0.0684	0.0690	0.0694	0.0698	0.0701	0.0703	0.0705	0.100287E-02
15	0.0042	0.0224	0.0566	0.0684	0.0742	0.0649	0.0665	0.0676	0.0683	0.0690	0.0693	0.0698	0.0701	0.0703	0.0705	0.916429E-03
16	0.0044	0.0221	0.0564	0.0682	0.0740	0.0648	0.0664	0.0675	0.0683	0.0690	0.0694	0.0697	0.0701	0.0703	0.0705	0.915003E-03
16	0.0047	0.0218	0.0562	0.0680	0.0739	0.0647	0.0664	0.0675	0.0683	0.0690	0.0694	0.0697	0.0701	0.0703	0.0704	0.914322E-03
16	0.0049	0.0215	0.0560	0.0678	0.0738	0.0647	0.0663	0.0675	0.0683	0.0690	0.0693	0.0697	0.0701	0.0703	0.0704	0.914322E-03
17	0.0051	0.0213	0.0558	0.0676	0.0737	0.0646	0.0663	0.0674	0.0682	0.0689	0.0694	0.0697	0.0701	0.0703	0.0704	0.871972E-03
17	0.0029	0.0218	0.0557	0.0674	0.0736	0.0645	0.0662	0.0674	0.0682	0.0688	0.0694	0.0697	0.0701	0.0702	0.0704	0.261408E-02
17	0.0032	0.0215	0.0555	0.0673	0.0735	0.0645	0.0662	0.0674	0.0682	0.0688	0.0694	0.0697	0.0701	0.0702	0.0704	0.877151E-03
17	0.0035	0.0212	0.0553	0.0671	0.0734	0.0644	0.0661	0.0673	0.0682	0.0688	0.0693	0.0697	0.0700	0.0702	0.0704	0.876457E-03
18	0.0037	0.0209	0.0552	0.0670	0.0732	0.0643	0.0661	0.0673	0.0681	0.0688	0.0693	0.0697	0.0700	0.0702	0.0704	0.835330E-03
18	0.0039	0.0206	0.0550	0.0668	0.0731	0.0643	0.0660	0.0672	0.0681	0.0688	0.0692	0.0697	0.0700	0.0702	0.0704	0.834709E-03
18	0.0042	0.0203	0.0548	0.0667	0.0730	0.0642	0.0660	0.0672	0.0681	0.0687	0.0692	0.0697	0.0700	0.0702	0.0703	0.833522E-03
18	0.0044	0.0201	0.0547	0.0665	0.0729	0.0642	0.0659	0.0672	0.0681	0.0687	0.0692	0.0696	0.0700	0.0702	0.0703	0.832935E-03
19	0.0046	0.0198	0.0545	0.0664	0.0728	0.0641	0.0659	0.0671	0.0680	0.0687	0.0692	0.0696	0.0700	0.0702	0.0703	0.832406E-03
19	0.0048	0.0195	0.0543	0.0663	0.0727	0.0640	0.0658	0.0671	0.0680	0.0687	0.0692	0.0696	0.0700	0.0702	0.0703	0.831875E-03
19	0.0050	0.0192	0.0541	0.0662	0.0726	0.0640	0.0658	0.0671	0.0680	0.0686	0.0692	0.0696	0.0700	0.0702	0.0703	0.249408E-02
19	0.0029	0.0197	0.0539	0.0661	0.0725	0.0639	0.0658	0.0670	0.0679	0.0686	0.0691	0.0695	0.0699	0.0701	0.0703	0.836659E-03
20	0.0032	0.0194	0.0538	0.0660	0.0724	0.0639	0.0657	0.0670	0.0679	0.0686	0.0691	0.0695	0.0699	0.0701	0.0703	0.836079E-03
20	0.0034	0.0191	0.0536	0.0659	0.0723	0.0638	0.0657	0.0670	0.0679	0.0686	0.0691	0.0695	0.0699	0.0701	0.0703	0.835510E-03
20	0.0036	0.0187	0.0534	0.0658	0.0722	0.0638	0.0656	0.0669	0.0679	0.0686	0.0691	0.0695	0.0699	0.0701	0.0703	0.834960E-03
20	0.0038	0.0184	0.0533	0.0657	0.0721	0.0637	0.0655	0.0669	0.0678	0.0685	0.0691	0.0695	0.0699	0.0701	0.0703	0.834429E-03
21	0.0038	0.0183	0.0531	0.0656	0.0721	0.0636	0.0655	0.0669	0.0678	0.0685	0.0691	0.0695	0.0699	0.0701	0.0703	0.834429E-03
21	0.0038	0.0182	0.0530	0.0655	0.0720	0.0636	0.0655	0.0668	0.0678	0.0685	0.0690	0.0694	0.0699	0.0701	0.0703	0.834429E-03
21	0.0038	0.0180	0.0529	0.0654	0.0719	0.0635	0.0654	0.0668	0.0678	0.0685	0.0690	0.0694	0.0699	0.0701	0.0703	0.834429E-03
21	0.0038	0.0179	0.0527	0.0653	0.0718	0.0635	0.0654	0.0667	0.0677	0.0685	0.0690	0.0694	0.0699	0.0701	0.0704	0.834429E-03
22	0.0038	0.0179	0.0526	0.0651	0.0718	0.0634	0.0654	0.0667	0.0677	0.0684	0.0690	0.0694	0.0699	0.0701	0.0704	0.693277E-03
22	0.0038	0.0179	0.0525	0.0649	0.0717	0.0634	0.0653	0.0667	0.0677	0.0684	0.0690	0.0694	0.0699	0.0701	0.0704	0.693277E-03
22	0.0038	0.0178	0.0524	0.0648	0.0716	0.0633	0.0652	0.0666	0.0676	0.0683	0.0690	0.0694	0.0698	0.0701	0.0704	0.693277E-03
22	0.0038	0.0178	0.0523	0.0646	0.0716	0.0633	0.0652	0.0666	0.0676	0.0683	0.0690	0.0694	0.0698	0.0701	0.0704	0.693277E-03
23	0.0038	0.0178	0.0522	0.0645	0.0715	0.0632	0.0652	0.0666	0.0676	0.0683	0.0690	0.0694	0.0698	0.0701	0.0704	0.708998E-03
23	0.0038	0.0177	0.0521	0.0644	0.0714	0.0632	0.0651	0.0665	0.0675	0.0683	0.0690	0.0694	0.0698	0.0701	0.0704	0.708998E-03
23	0.0038	0.0177	0.0520	0.0643	0.0714	0.0632	0.0651	0.0665	0.0675	0.0683	0.0690	0.0694	0.0698	0.0701	0.0704	0.708998E-03
23	0.0038	0.0176	0.0519	0.0642	0.0713	0.0631	0.0651	0.0665	0.0675	0.0682	0.0689	0.0694	0.0697	0.0701	0.0704	0.708998E-03
24	0.0038	0.0175	0.0518	0.0640	0.0712	0.0631	0.0650	0.0664	0.0675	0.0682	0.0689	0.0694	0.0697	0.0701	0.0704	0.708998E-03
24	0.0038	0.0175	0.0517	0.0639	0.0711	0.0630	0.0650	0.0664	0.0674	0.0682	0.0689	0.0694	0.0697	0.0701	0.0704	0.708998E-03
24	0.0038	0.0174	0.0516	0.0638	0.0711	0.0630	0.0649	0.0664	0.0674	0.0682	0.0689	0.0694	0.0697	0.0700	0.0704	0.708998E-03
24	0.0038	0.0173	0.0515	0.0637	0.0710	0.0629	0.0649	0.0663	0.0674	0.0681	0.0689	0.0693	0.0697	0.0700	0.0704	0.708998E-03

PART 3.—EMERGE: A SIMULATION OF COTTON GERMINATION AND EMERGENCE

By D. F. Wanjura¹

DESCRIPTION

The following pages contain a short description and detailed instructions for using the computer model of cotton emergence, EMERGE. A comprehensive discussion of the theory and logic utilized in EMERGE is given by Wanjura et al.² Validation of EMERGE and its application for studying the sensitivity of cotton emergence to several soil parameters have been documented by Wanjura.³

EMERGE simulates the time distribution of cotton seedling emergence. Theoretical equations that describe water absorption by seeds and elongation of the cotton hypocotyl, with accompanying logic, form the basis of the model. Parameter values for the theoretical equations and the logic were derived from experimental data and other observations obtained from emergence tests conducted under controlled environmental conditions. Parameter values in the equations are dependent functions of the soil environment. In this manner the equations reflect the effect of temperature, moisture, and physical impedance of the soil on the emerging seedlings.

Cotton emergence is divided into two phases in EMERGE. Within each phase the average performance of a population of emerging seedlings is described. The first phase is germination, which is followed by the second phase, called

emergence. Germination extends from the time of planting until the average radicle length reaches 3 mm. Germination progress is related to water absorption rate, which is dependent on soil temperature and moisture. Water absorption rate increases between 60° and 100° F, but is assumed to stop below 60° F and level off above 100° F. Germination (or 3-mm radicle length) is considered to have occurred when the moisture content of the seed exceeds a specific level for a given temperature and soil moisture. These specific seed-moisture levels were determined from empirical data.

Emergence begins with the completion of germination and depends on soil temperature, moisture, and physical impedance. Emergence progress is related to the average hypocotyl elongation of the seedling population. The temperature limits for hypocotyl elongation are 60° and 104° F. Temperatures outside this range are assumed to stop or interrupt hypocotyl elongation.

Seedling emergence is calculated from a set of regression equations. These equations were developed from experimental data relating average hypocotyl length and soil-moisture level to the percentage of seedlings which exceed certain specific lengths. In the model, the specific lengths represent planting depths. For example, if the hypocotyl elongation portion of the model indicates average hypocotyl length as 4 cm, with a planting depth of 3.8 cm, and if the percentage of seedlings equal to or greater than 3.8 cm in length is 50 %, as calculated with the appropriate regression equation, then 50 % emergence has occurred from a 3.8-cm planting depth. Percentage emergence, of course, would be lower if the planting depth was greater for the same average hypocotyl length.

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² Wanjura, D. F., Buxton, D. R., and Stapleton, H. N. 1973. A model for describing cotton growth during emergence. *Trans. ASAE (Am. Soc. Agric. Eng.)* 16: 227-231.

³ Wanjura, D. F. 1973. Effect of physical soil properties on cotton emergence: Prediction and quantitative description. U.S. Dep. Agric. Tech. Bull. No. 1481, 20 pp.

LIMITATIONS

The temperature range of EMERGE extends from 60° to 104° F. Soil temperatures are measured hourly at seed level.

Soil-moisture tension can vary from 0.33 to 11 bars. Soil moisture should be sampled in the interval including seed depth ± 0.64 cm at least every 2 days. When the soil dries to seed depth after germination, soil moisture should then be sampled in the zone where the seedling radicle is absorbing moisture from the soil.

Soil physical impedance is the input parameter most difficult to describe numerically. The values used in developing EMERGE were measurements made in soil that was uniformly compacted from seed level to the soil surface. Even though the same type of soil penetrometer (0.4-cm-diameter blunt end) is used both in the field and in the laboratory, the same physical impedance reading on the penetrometer could represent different magnitudes of soil resistance to seedling emergence. Rarely in the field is the physical impedance level in the soil uniformly distributed with depth. The permissible range of physical impedance values for the covering soil over the seed is 3.3 to 50 lb/in² (PI in program). Physical impedance should be measured by inserting the penetrometer 2.5 cm into the covering soil over the seed drill. Measurements should be taken at least every 2 days

Planting depth designations are limited to

1.25-cm increments between 1.3 and 7.5 cm. If the depth of soil over the seed changes after planting, the time of change and the amount must be reflected in the computer coding of EMERGE where planting depth (DEPTH) is specified.

There is no algorithm in EMERGE to describe changes in seed vigor that may occur after planting. Thus, if long periods of adverse temperature or saturated soil are encountered, EMERGE may produce an inaccurate simulation because seed germination percentage has changed. The model was developed from experimental data on acid-delinted seed; however, it should be suitable for situations where fuzzy seed is planted.

Henry D. Bowen and James W. Jones at North Carolina State University suggest the following modification of EMERGE. The present method of calculating the limits of hypocotyl elongation (EST) for a low-temperature period followed by a warm period predicts lower growth rates than observed. If EST is calculated by using a running average, the accuracy for the above conditions is improved. At the same time, the accuracy under normal warming conditions is not affected. North Carolina has programed EMERGE for IBM 360 FORTRAN with the option of EST being calculated with or without using a running average.

DEFINITION OF TERMS

A	Array of hourly seed-level soil temperatures in degrees Fahrenheit.	EM	Array for storing hourly EST values prior to printing as output.
CLOK	Counter for accumulating time in hours.	EP	Array for storing cumulative percentage emergence values prior to printing as output.
DE	Hypocotyl elongation during 1 hour, in centimeters.	EST	A three-dimensional array of maximum hypocotyl lengths used to calculate hypocotyl elongation.
DELMOS	Seed-moisture increase during the hour preceding germination.	GERMT	Elapsed time from planting when germination occurs in hours.
DEPTH	Planting depth in centimeters.	GP	Standard seed germination in percent.
DT	Array for storing the calculated hourly fractional accumulated increments of growing time prior to printing as output.	IDATE	Date of test.
DWATER	Hourly increase in seed moisture in percent, dry weight.	J	Counter for accumulating time in hours.
EL	Array for storing accumulated hypocotyl lengths in centimeters prior to printing as output.	KL	Parameter used in calculating rate of seed-moisture uptake.
ELONG	Accumulated length of hypocotyl in centimeters.	KNL	Array for storing hourly KT values prior to printing as output.
ELST	Accumulated hypocotyl length in centimeters.	KT	A three-dimensional array of rate of elongation parameter values used to calculate hypocotyl elongation.
		M	Seed-level soil-moisture tension in bars.

MOIST	Subroutine in which time variation of seed-level soil moisture is specified.	TIME	Array for storing time values in hours prior to printing as output.
NDEPTH	Integer value of DEPTH.	TMAX	Total allowable emergence time for the soil environmental conditions existing during the hour.
PI	Soil physical impedance in pounds per square inch.	TWATER	Accumulated seed moisture in percent, dry weight.
PLACE	Variable for identifying location of test.	TWATERL	Parameter for temporarily storing the value of accumulated seed moisture in percent, dry weight.
S	TEMP.		
TEMP	Seed-level soil temperature in degrees Celsius.		
TIM	Time in hours.		

INPUT/OUTPUT

Input

Program inputs read in as data are arranged in the following order and formats:

1. A table of KT values is read under 5F 10.0 format. These data are included with the source deck, which can be obtained from the author. The KT values do not appear in the output section.

2. A table of EST values is read under 5F 10.0 format. These data are also included with the source deck and do not appear in the output section.

The following data must appear in sequence after input 2 and be supplied by the user:

3. PLACE, M, PI, IDATE, DEPTH, and GP on one card in A10, F5.0, F5.0, 5X, A10, and 2F5.2 format.

4. A-array (hourly seed-level soil temperatures) arranged in 16F5.0 format on each card. The last card should have 9999. punched in the first five spaces. The number of hours simulated is equal to the number of A-array values. A maximum of 500 values may be specified.

The following information is required input, but does not appear in the data section of the program deck; necessary changes must be made di-

rectly in the main program.

5. The variation of seed-level soil moisture (M) over time is specified in subroutine MOIST. This information must be supplied by the user in FORTRAN statements.

6. Physical impedance (PI) variation over time is specified in the main program where indicated by comment cards. The change in physical impedance must be described by the user in FORTRAN statements.

Output

The first information printed out is identifying data for the simulation, including location, beginning seed-level soil moisture, initial soil physical impedance, and date. This information is printed under the format of statement 31.

During germination the parameters CLOK, TEMP, M, KL, DWATER, DELMOS, and TWATER are printed hourly in 7F10.5 format.

When seed germination is reached this is printed under the format of statement 52—GERMINATION TIME EQUALS "F5.0."

During the emergence phase of EMERGE, hourly values of TIME, A, DE, EL, KNL, EM, DT, and EP are printed according to the format of statement 34.

PROGRAM SETUP AND EXECUTION

EMERGE is programed in FORTRAN for a CDC 6400 computer.

EMERGE does not use any special system functions that are peculiar to a CDC 6400. Some variable names are seven characters long, which is a greater word length than most other computers allow. The CDC 6400 also permits the "A format" specification to be a maximum of A (10).

The standard code read by a CDC 6400 is BCD. Computers which have EBCDIC as the standard code may not read cards punched with

BCD code. Normally, computers can read either code, provided an appropriate control card is utilized.

The card deck is arranged in the following sequence:

- A. Control cards
 1. Job card
 2. RUN(S)
 3. SETCORE
 4. LGO

End-of-record card: Multiple-punch 7-8-9 in card column 1

- B. Main program deck
- C. Subroutines
 - End-of-record card: Multiple-punch 7-8-9 in card column 1
- D. Data
 - End-of-file card: Multiple punch 6-7-8-9 in card column 1

The RUN(S) card in the control card section causes the computer to compile EMERGE. All memory locations in the computer are zeroed by the SETCORE card. The LGO card causes the

program to be executed. In addition to the initializing accomplished by the LGO card, some variables are initially set equal to zero in the main program. However, for the control cards indicated for running on a CDC 6400, initializing within the main program is redundant. To compile EMERGE requires 10,112 memory locations. Program execution uses 9,984 memory locations. Computer compilation and execution time required to simulate a 10-day emergence period is approximately 5.2 seconds of central processor time.

PROGRAM LISTING

PROGRAM EMERGE(INPUT,OUTPUT,TAPE1=INPUT)

*****SECTIONS SUBJECT TO CHANGE FOR SIMULATION ARE AS FOLLOWS****

***** (1) MOISTURE, BARS-- THIS IS IN A SUBROUTINE

***** (2) PHYSICAL IMPEDANCE, PSI

```

000003      DIMENSION KT(6,4,5), FST(6,4,5)
000003      DIMENSION A(500), DF(500), TIME(500), EL(500),
000003      1KNL(500), EM(500), FP(500), DT(500)
000003      REAL M,K,KNL,KL
000003      READ 70,((KT(I,J,L),L=1,5),J=1,4),I=1,6)
000030      PRINT 8A
000034      READ 70,((FST(I,J,L),L=1,5),J=1,4),I=1,6)
000061      20 READ 30, PLACE, M, PI, IDATE, DEPTH, GP
000101      PRINT 31, PLACE, M, PI, IDATE
000115      1 PRINT 40
000121      70 FORMAT(5F10.0)
000121      88 FORMAT(2H//)
000121      40 FORMAT(///,5X,*TIME*,6X,*TEMP*,5X,*MOS*,8X,*KL*,6X,
000121      1*DWATER*,5X,*DELMOS*,3X,*TWATER*/)
000121      50 FORMAT(16F5.0)
000121      51 FORMAT(7F10.5)
000121      52 FORMAT(//10X,*GERMINATION TIME EQUALS*,F5.0,2X,*HOURS*//)
000121      30 FORMAT(A10,F5.0,F5.0,5X,A10,2F5.2)
000121      31 FORMAT(1H1,20X,*LOCATION:*,1X,A10,3X,*MOISTURE:*,F5.2,
000121      13X,*PHYSICAL IMPEDANCE:*,F5.1,3X,*DATE:*,1X,A10//)
000121      GD= GP/100.

```

**** INITIALIZATION OF PARAMETERS

```

000123      TWATERL=0.
000124      DWATER=0.
000125      CLOK= 0.
000126      GFRMT= 0.
000127      ELONG=0.
000130      CLOK= 0.
000131      DT(J) = 0.
000134      ELST= .05
000136      EL(J)= 0.
000141      ELONG= 0.
000142      PI= 3.3
000143      60 J=0
000144      500 READ 50,(A(Y), Y= 1,500)
000157      IF(EOF,1)61,500

```

***** THIS SECTION COMPUTES THE 3-MM RADICLE EMERGENCE EVENT
 ***** BY SIMULATING THE IMBITTIONAL WATER UPTAKE OF COTON
 ***** SEED. THE INPUTS ARE HOURLY SOIL TEMPERATURE F, AND
 ***** SOIL MOISTURE IN BARS.

```

000162      61 J=J+1
000164      CALL MOTST(M, CLOK)
000166      IF(A(J).GT.100.) A(J)= 100.
000175      TEMP=(A(J)-32.)*.55555555

```

PROGRAM LISTING—Continued

```

000203      CLOK= CLOK + 1.
000205      IF(TEMP.LT.15.55555) GO TO 15
000210      IF(TEMP.GF.32.22220) GO TO A9
000213      IF(TEMP.GF.15.55555) GO TO 90
000216      A9 KL= -.05171368 + .000149960*(TEMP**2.) + .0343398A*M
          1 = .0006448513*(M **2.) = .0009024209*TFMP*M
000236      GO TO 91
000236      90 KL= .0337762 + .0000855456*TEMP**2. = .003478A2*M
000247      91 DWATER=KL*(A0.0 = TWATERL)
000253      IF((TFMP.GE.26.66).AND.(TFMP.LT.32.2)) GO TO 63
000265      IF(TEMP.GT.32.2) GO TO 66
000270      IF((TFMP.GT.21.2).AND.(TEMP.LT.26.66)) GO TO 65
000302      IF((TFMP.LE.21.2).AND.(TEMP.GE.15.55)) GO TO 62
000315      62 DELMOS= .1133196 + .000705254*(TEMP**2.) = .00134777A*
          1M + .001177446*(M **2.)
000333      GO TO 64
000333      63 DELMOS= -.6954544 + .001961955*(TFMP**2.) + .0833515*
          1M + .007626679*(M **2.) = .006411228*M *TFMP
000353      GO TO 64
000353      65 DELMOS= -.3583704 + .001383181*(TFMP**2.) = .0350919A*
          1M + .00350674A*(M **2.)
000371      GO TO 64
000371      66 DELMOS= 3.39290A = .00197022*(TFMP**2.) = .3693547*M
          1 + .008647528*(M **2.) + .007306203*TEMP*M
000411      64 IF(DWATER.LT.DELMOS)GO TO 10
000414      TWATER= TWATERL + DWATER
000416      GO TO 16
000417      15 KL=0.0
000420      DWATER=0.0
000421      DELMOS=0.0
000422      TWATER=TWATERL
000424      16 PRINT 51,CLOK, TEMP, M, KL, DWATER, DELMOS, TWATER
000446      TWATERL=TWATER
000450      GO TO 61
000450      10 TWATER=TWATERL + DWATER
000452      PRINT 51,CLOK, TEMP, M, KL, DWATER, DELMOS, TWATER
000474      GERMT= CLOK
000476      PRINT 52, GERMT
000503      DWATER=0.
000504      TWATERL=0.
000505      GO TO 502

```

C**** THIS SECTION CALCULATES HYPOCOTYL ELONGATION IN CM
 C**** USING HOURLY INPUTS OF SOIL TEMPERATURE F, SOIL
 C**** MOISTURE IN BARS, AND PHYSICAL IMPEDANCE IN PSI

```

000506      502 KKK= GERMT
000510      KN= KKK + 1
000512      J= KKK
000513      TIM= J
000514      22 FORMAT( 1X,*TIME*,2X,*TEMPERATUREF*,5X,*DF*,9X,
          1*ELONGATION*,13X,*KNL*,12X,*EMAXT*, 6X,*DTIME*, 4X,*FMPFRCENT*)
000514      34 FORMAT( 1X,F4.0,5X,F4.0,7X,F5.3,8X,F7.3,10X,F15.10,5X
          1,F5.2,7X,F6.5,3X,F5.1)
000514      73 J= J + 1
000516      TIM= TIM + 1.

```


PROGRAM LISTING—Continued

```

000520      T= A(J)
000523      IF(T.GT. 999.) GO TO 501
000526      IF((T.LT.60.).OR.(T.GT.104.)) GO TO 46

C**** PHYSICAL IMPEDANCE IS INCREASED WHEN AVERAGE HYPOCOTYL LENGTH
C**** EQUALS PLANTING DEPTH. IN CALIBRATING THE MODEL, IT WAS
C**** FOUND THAT THE FIELD MEASURED PT VALUES EXPRESSED IN PSI SHOULD
C**** BE DIVIDED BY 10. THE LOWEST PERMISSIBLE PT VALUE IS 3.3. IN
C**** GENERAL PT VALUES OF 6, 12, AND 20 ARE REPRESENTATIVE OF LIGHT,
C**** MEDIUM, AND SEVERE SOIL PHYSICAL IMPEDANCES.

000541      IF(FLONG.GE.DEPTH)GO TO 144
000544      GO TO 145

C**** PT IS DESCRIBED IN STATEMENT 144

000545      144 IF((TIM.GF.195.).AND.(TIM.LT.243.))PI=6.3-.054*(TIM-195.)
000563      IF((TIM.GF.243.).AND.(TIM.LT.338.))PI=3.7-.0178*(TIM-243.)
000601      IF(TIM.GE.338.)PI=4.5
000605      IF(PI.LT.3.3)PI=3.3
000611      145 CALL MOTST(M,TIM)
000613      KNL(J) = K(T,M,PI,KT)
000622      EM(J) = K(T,M,PI,EST)
000631      DE(J)= KNL(J)*ELST*(EM(J) - ELST)
000643      S= (T - 32)*.555555
000647      IF(S.LT.21.1111) GO TO 74
000652      IF((S.GF.21.1111).AND.(S.LE.32.2222)) GO TO 75
000665      IF(S.GT.32.2222) GO TO 92
000670      74 CON= .202744E=06
000672      TMAX=492.999 =CON*EXP(S) = 17.6902*M = 1.50139*(M**2)
           1+ 2.76729*M
           GO TO 93
000707      75 DON= .036166E=12
000710      TMAX=471.445 = 13.6641*S + DON*EXP(S) + 62.4350*M
000712      1= 2.35855*(M**2) = .548660*S*M
           GO TO 93
000732      92 TMAX=82.8845+96.9449*M-2.25039*(M**2)-1.69967*S*M
000732      93 DT(J)= 1.0/TMAX + DT(J-1)
000745      IF(EM(J).LT.ELST) GO TO 47
000754      EL(J)= FL(J-1) + DE(J)
000761

C**** THIS SECTION COMPUTES PERCENTAGE EMERGENCE FROM THE AVERAGE
C**** HYPOCOTYL LENGTH(FL(J))

000771      IF(FLONG.LT.1.0) GO TO 252

C**** THIS SECTION CALCULATES THE STATEMENT NUMBER OF THE EQUATION
C**** TO BE USED IN CALCULATING PERCENTAGE EMERGENCE. THE CORRECT
C**** EQUATION DEPENDS ON PLANTING DEPTH.

000774      IF(DEPTH.LT.1.875)GO TO 1000
000777      IF(DEPTH.GE.6.875)GO TO 1001
001002      NDEPTH=(DEPTH/1.25) + .5
001006      GO TO 1002
001007      1000 NDEPTH=1
001011      GO TO 1002

```

PROGRAM LISTING—Continued

```

001011      1001 NDEPTH=6
001013      1002 GO TO(200,201,202,203,204,205),NDEPTH

C      APPLICABLE RANGE OF ELONG IS 1.0 = 4.8 CM.  DEPTH= 1.3 CM
001025      200 EP(J)=48.4553*ELONG - 6.67388*(ELONG**2) + .239116*(ELONG**3) - .8
126568*ELONG*M
001046      GO TO 250
C      APPLICABLE RANGE OF ELONG IS 1.0 = 5.6 CM.  DEPTH = 2.5 CM
001047      201 IF((ELONG.LT.1.0).OR.(ELONG.GT.6.7)) GO TO 250
001062      EP(J)= -22.8372*ELONG + 24.9413*(ELONG**2) - 3.81217*(ELONG**3)
1+ .0204049*(ELONG**5)
001105      GO TO 250
C      APPLICABLE RANGE OF ELONG IS 1.0 = 6.6 CM.  DEPTH= 3.8 CM
001106      202 IF((ELONG.LT.1.4).OR.(ELONG.GT.6.6))GO TO 250
001121      EP(J)= 4.34967*M-12.9137*ELONG+7.47138*(ELONG**2)-.0123471*(E
1LONG**5) - 2.06569*ELONG*M
001144      GO TO 250
C      APPLICABLE RANGE OF ELONG IS 1.0 = 7.5 CM.  DEPTH= 5.0 CM
001145      203 EP(J)=11.6959*FLONG + 5.09969*(ELONG**2) - .0354686*(ELONG**4) +
11.37004*(M**2) - 1.3153*ELONG*M
001173      GO TO 250
C      APPLICABLE RANGE OF ELONG IS 1.0 = 7.5 CM.  DEPTH= 6.3CM
001174      204 EP(J)=12.0228*M + 13.1315*FLONG - 8.56872*(ELONG**2) + 1.61419*(F
1LONG**3) - .00985923*(ELONG**5) + 3.11801*(M**2) + .99203A*ELONG*M
001231      GO TO 250
C      APPLICABLE RANGE OF ELONG IS 2.4 = 7.5 CM.  DEPTH= 7.5 CM
001232      205 IF((ELONG.LT.3.5).OR.(ELONG.GT.7.5)) GO TO 250
001245      EP(J)=8.48373*M + 5.0013*ELONG - 1.53460*(ELONG**3) + .438285*(EL
1ONG**4) - .0303805*(ELONG**5) + 2.0752*(M**2) + .813498*ELONG*M
001302      250 EP(J)= EP(J)*GD
001307      IF(EP(J).LT.EP(J-1)) EP(J)= EP(J-1)
001322      252 ELST= DE(J) + ELST
001326      ELONG= FL(J)
001331      TIME(J)= TIM
001334      GO TO 73
001335      46 DE(I)= 0.
001340      KNL(J)= 0.
001343      EM(I)= 0.
001346      TIME(J)= TIM
001351      EL(J)= FL(J-1)
001356      DT(J)= DT(J-1)
001363      EP(J)= EP(J-1)
001370      GO TO 73
001371      47 DE(I)= 0.
001374      TIME(J)= TIM
001377      EL(J)= FL(J-1)
001404      EP(I)= EP(J-1)
001411      GO TO 73
001412      501 PRINT 22
001416      PRINT 34,(TIME(I), A(I), DE(I), EL(I), KNL(I), EM(I), DT(I), EP(I)
1,I=KN.J)
001457      STOP
001461      END

```

SUBROUTINE MOIST(M, TCLK)

C**** THE SECTION BELOW EXPRESSES THE MOISTURE IN THE SEED ZONE AS A
C**** FUNCTION OF TIME FOR A PARTICULAR FIELD TEST

PROGRAM LISTING—Continued

```

000006      REAL M
000006      IF(TCLOCK.LT.122.)M=.9
000011      IF((TCLOCK.GE.122.).AND.(TCLOCK.LT.168.))M=.9+.0108*(TCLOCK-122.)
000027      IF((TCLOCK.GE.168.).AND.(TCLOCK.LT.216.))M=1.4
000042      IF((TCLOCK.GE.216.).AND.(TCLOCK.LT.289.))M=1.4+.0137*(TCLOCK-216.)
000060      IF((TCLOCK.GE.289.).AND.(TCLOCK.LT.338.))M=2.4+.0122*(TCLOCK-289.)
000076      IF(TCLOCK.GE.338.)M=3.
000102      RETURN
000103      END

```

REAL FUNCTION K(T,M,PT,KT)

C**** THIS FUNCTION CALCULATES THE VALUE OF EMAXT AND KNL FOR HYPOCOTYL
C**** ELONGATION AS A FUNCTION OF TEMPERATURE F, MOISTURE IN BARS, AND
C**** PHYSICAL IMPEDANCE IN PSI BY USING LINEAR INTERPOLATION IN TWO OR
C**** THREE DIMENSIONS

```

000011      DIMENSION TA(6),MA(4),PIA(5)
000011      DIMENSION KT(6,4,5)
000011      REAL MA,KT,M,KL,KII,KSIIB
000011      DATA TA/60.0,70.0,80.0,90.0,100.0,104.0/,MA/0.33,3.0,
110.0,11.0/,PIA/3.3,16.0,32.0,48.0,50.0/
000011      ITL=ITU=0
000013      DO 1 I=1,6
000014      IF(T.GE.TA(I)) GO TO 1
000020      ITL=I-1
000022      ITU=I
000023      GO TO 3
000024      1 CONTINUE
000026      3 DT=(T-TA(ITL))/(TA(ITU)-TA(ITL))
000041      IF(DT.EQ.0.) ITU=ITL
000043      IMU=IML=0
000045      DO 2 I=1,4
000047      IF(M.GE.MA(I)) GO TO 2
000053      IML=I-1
000055      IMU=I
000056      GO TO 4
000057      2 CONTINUE
000061      4 DM=(M-MA(IML))/(MA(IMU)-MA(IML))
000074      IF(DM.EQ.0.) IMU=IML
000076      IPL=IPU=0
000100      DO 5 I=1,5
000102      IF(PI.GE.PIA(I)) GO TO 5
000106      IPL=I-1
000110      IPU=I
000111      GO TO 6
000112      5 CONTINUE
000114      6 DP=(PI-PIA(IPL))/(PIA(IPU)-PIA(IPL))
000127      IF(DP.EQ.0.) IPU=IPL
000131      D=SQRT(DP**2. + DM**2. + DT**2.)
000151      KL=KT(ITL,IML,IPL)
000162      KII=KT(ITU,IMU,IPU)
000171      11 IF((DT.GT.0.).AND.(DM.GT.0.)) GO TO 12
000203      IF((DT.GT.0.).AND.(DP.GT.0.)) GO TO 13

```

C CALCULATION OF K WHEN MOISTURE AND PHYSICAL IMPEDANCE ARE
C BETWEEN TABLE VALUES

PROGRAM LISTING—Continued

```

000215      9 K=D*(KU=KL) + KL
000222      GO TO 10

C      CALCULATIONS TO FIND PROPER VALUE OF K WHEN TEMPERATURE AND
C      MOISTURE ARE BETWEEN TABLE VALUES

000222      12 IF(DP.GT.0.) GO TO 14

000225      DTFML=(MA(IML)-M)/(MA(IML)-MA(IMU))
000240      SUBL1=(DTFML)*(KT(ITL,TML,TPL)-KT(ITL,IMU,TPL))
000255      SUBL2=KT(ITL,IML,IPL)-SURL1
000265      DTFMU=(MA(IML)-M)/(MA(IML)-MA(IMU))
000300      SUBU1=(DTFMU)*(KT(ITU,TML,TPL)-KT(ITU,IMU,TPL))
000315      SUBU2=KT(ITU,IML,IPL)-SURU1
000325      KSUB=((SUBU2-SURL2)*(TA(ITU)-T))/(TA(ITU)-TA(ITL))
000344      K= SURU2 - KSUB
000346      GO TO 10

C      CALCULATIONS OF K WHEN TEMPERATURE AND PHYSICAL IMPEDANCE ARE
C      BETWEEN TABLE VALUES

000346      13 IF(DM.GT.0.) GO TO 14
000351      DTFML=(PIA(IPL)-PI)/(PIA(IPL)-PIA(IPU))
000364      SUBL1=(DTFML)*(KT(ITL,TML,TPL)-KT(ITL,TML,TPL))
000401      SUBL2=KT(ITL,IML,IPL)-SURL1
000411      DTFMU=(PIA(IPL)-PI)/(PIA(IPL)-PIA(IPU))
000424      SUBU1=(DTFMU)*(KT(ITU,TML,TPL)-KT(ITU,TML,TPL))
000441      SUBU2=KT(ITU,IML,IPL)-SURU1
000451      KSUB=((SUBU2-SURL2)*(TA(ITU)-T))/(TA(ITU)-TA(ITL))
000470      K= SURU2 - KSUB
000472      GO TO 10
000472      15 IF(DT.GT.0.) GO TO 14
000475      DTFML=(MA(IML)-M)/(MA(IML)-MA(IMU))
000510      SUBL1=(DTFML)*(KT(ITL,TML,TPL)-KT(ITL,IMU,TPL))
000525      SUBL2=KT(ITL,IML,IPL)-SURL1
000535      DTFMU=DTFML
000536      SUBU1=(DTFMU)*(KT(ITL,TML,TPL)-KT(ITL,IMU,TPL))
000553      SUBU2=KT(ITL,IML,IPL)-SURU1
000563      KSUB=((SUBU2-SURL2)*(PIA(IPU)-PI))/(PIA(IPU)-PIA(IPL))
000602      K= SURU2 - KSUB
000604      GO TO 10

C      CALCULATION OF K WHEN TEMPERATURE, MOISTURE, AND PHYSICAL
C      IMPEDANCE ARE BETWEEN TABLE VALUES

000604      14 DIFSQ=SQRT(DM**2 + DP**2)
000620      SUBL1=DIFSQ*(KT(ITL,TML,TPL)-KT(ITL,IMU,IPU))
000640      SUBL2=KT(ITL,IML,IPL)-SURL1
000650      SUBU1=DIFSQ*(KT(ITU,TML,TPL)-KT(ITU,IMU,TPL))
000665      SUBU2=KT(ITU,IML,IPL)-SURU1
000675      KSUB=((SUBU2-SURL2)*(TA(ITU)-T))/(TA(ITU)-TA(ITL))
000714      K= SURU2 - KSUB
000716      10 RETURN
000720      END

```

EXAMPLE RUN

Input Data

TABLE OF KT VALUES

.C0480832	.010383691	.0139727
.C08352267	.013597265	.C162947
.C113208	.C0705326	
.C0501412	.013159308	.C187783
.C0469919	.CC920764	.C172229
.C113818	.0138237	.C133494
.C0788747	.0128454	.0152562
.C0444414	.C07950115	.C190638
.C0557594	.0122496	.C226051
.C08331056	.015699449	.C271838
.C0050000	.CC975761	.C198626
.C0651485	.0162866	.C562627
.C0898465	.0149086	.C330927
.C58517036	.0435381	
.C000000	.CCCC00	.CCCC00

TABLE OF EST VALUES

.C192581	2.75	1.25	.85	.55
.C199945	1.65	.75	.55	.35
.C102575	.75	.25	.15	.25
.C200439	7.85	3.05	1.65	1.35
.C198467	4.95	2.85	1.45	.95
	1.15	.75	.35	.15
.C252810	8.25	3.55	2.35	1.55
.C252810	6.25	3.50	1.55	1.05
.C431408	2.95	.65	.35	.25
.C485776	9.85	4.15	2.25	1.25
.C263540	7.55	2.95	1.55	.65
	3.55	1.05	.35	
.C625105	7.05	2.75	1.55	.75
	.45	.25		
.CCCC00	0.00	0.00	0.00	0.00

PLACE M PI IDATE DEPTH GP

LU880CK 1.0 3.3 4-28-71 5.0089.00

SEED-LEVEL TEMPERATURES

69	68	69	69	69	68	67	65	64	62	61	60	59	58	57	56
55	54	54	55	58	62	68	72	75	78	79	79	78	76	74	71
69	67	66	65	64	63	62	62	61	61	61	61	65	68	72	75
80	83	84	84	82	81	78	74	72	71	69	67	67	65	63	63
61	60	60	62	63	67	71	74	76	79	80	80	79	78	76	74
72	70	68	67	66	64	64	62	61	61	61	62	65	68	74	76
80	82	83	83	82	81	78	76	74	73	71	70	69	68	67	66
65	64	63	64	65	68	71	74	76	79	80	81	80	79	77	75
73	72	71	70	69	68	67	66	65	65	65	66	68	70	74	77
79	80	80	80	79	78	77	76	75	74	73	72	71	69	68	66
64	63	63	64	66	68	72	75	77	79	80	80	79	78	76	74
73	71	69	68	66	65	64	63	62	61	61	63	66	67	71	76
79	81	82	80	79	78	77	74	72	70	70	68	67	65	65	64
64	63	63	64	66	68	71	76	78	82	84	84	84	82	80	77
75	73	71	70	69	68	67	66	65	65	64	65	65	66	67	68
71	73	73	73	72	71	69	68	67	66	66	65	65	65	65	65
65	65	66	67	69	72	71	77	79	80	81	80	79	77	75	72
71	68	67	67	64	63	63	62	61	61	63	66	68	72	74	80
81	82	83	82	81	79	76	73	73	73	71	70	69	68	67	66
65	64	64	64	66	68	70	72	73	73	74	75	73	73	71	69
68	68	66	65	64	63	62	62	61	60	60	61	63	65	67	69
72	74	76	76	76	76	74	73	69	66	65	63	62	60	58	57
57	55	54	54	57	63	65	70	74	77	80	81	82	81	79	76
74	71	69	68	66	65	63	62	60	60	58	59	60	65	69	71
76	79	80	81	81	79	78	74	72	71	70	68	67	66	66	65

9999.

Output Data

LOCATION: LUMBOCK MOISTURE: 1.00 PHYSICAL IMPEDANCE: 3.3 DATE: 4-28-71

TIME	TEMP	MOS	KL	DWATER	DELMOS	TWATER
1.00000	20.55556	.90000	.06679	5.34327	.18441	5.34327
2.00000	20.00000	.90000	.06486	4.84250	.16852	10.18577
3.00000	20.55556	.90000	.06679	4.66296	.18441	14.84873
4.00000	20.55556	.90000	.06679	4.35151	.18441	19.20024
5.00000	20.55556	.90000	.06679	4.06087	.18441	23.26111
6.00000	20.00000	.90000	.06486	3.68028	.16852	26.94139
7.00000	19.44444	.90000	.06299	3.34210	.15307	30.28350
8.00000	18.33333	.90000	.05940	2.95307	.12346	33.23656
9.00000	17.77778	.90000	.05768	2.69740	.10932	35.93397
10.00000	16.66667	.90000	.05441	2.39754	.08233	38.33151
11.00000	16.11111	.90000	.05285	2.20219	.06948	40.53369
12.00000	15.55556	.90000	.05135	2.02640	.05708	42.56010
13.00000	15.00000	.90000	0.00000	0.00000	0.00000	42.56010
14.00000	14.44444	.90000	0.00000	0.00000	0.00000	42.56010
15.00000	13.88889	.90000	0.00000	0.00000	0.00000	42.56010
16.00000	13.33333	.90000	0.00000	0.00000	0.00000	42.56010
17.00000	12.77778	.90000	0.00000	0.00000	0.00000	42.56010
18.00000	12.22222	.90000	0.00000	0.00000	0.00000	42.56010
19.00000	12.22222	.90000	0.00000	0.00000	0.00000	42.56010
20.00000	12.77778	.90000	0.00000	0.00000	0.00000	42.56010
21.00000	14.44444	.90000	0.00000	0.00000	0.00000	42.56010
22.00000	16.66667	.90000	.05441	2.03703	.08233	44.59713
23.00000	20.00000	.90000	.06486	2.29635	.16852	46.89348
24.00000	22.22222	.90000	.07289	2.41313	.29594	49.30661
25.00000	23.88889	.90000	.07946	2.43903	.40224	51.74964
26.00000	25.55556	.90000	.08651	2.44440	.51622	54.19004
27.00000	26.11111	.90000	.08897	2.29630	.55593	56.48634
28.00000	26.11111	.90000	.08897	2.09200	.55593	58.57833
29.00000	25.55556	.90000	.08651	1.85327	.51622	60.43161
30.00000	24.44444	.90000	.08176	1.59994	.43938	62.03155
31.00000	23.33333	.90000	.07722	1.38753	.36595	63.41907
32.00000	21.66667	.90000	.07080	1.17400	.26721	64.59307
33.00000	20.55556	.90000	.06679	1.02904	.18441	65.62211
34.00000	19.44444	.90000	.06299	.90565	.15307	66.52776
35.00000	18.88889	.90000	.06117	.82406	.13805	67.35182
36.00000	18.33333	.90000	.05940	.75128	.12346	68.10310
37.00000	17.77778	.90000	.05768	.68624	.10932	68.78933
38.00000	17.22222	.90000	.05602	.62800	.09560	69.41734
39.00000	16.66667	.90000	.05441	.57578	.08233	69.99312
40.00000	16.66667	.90000	.05441	.54445	.08233	70.53757
41.00000	16.11111	.90000	.05285	.50009	.06948	71.03766
42.00000	16.11111	.90000	.05285	.47366	.06948	71.51132
43.00000	16.11111	.90000	.05285	.44863	.06948	71.95995
44.00000	16.11111	.90000	.05285	.42492	.06948	72.38487
45.00000	18.33333	.90000	.05940	.45232	.12346	72.83719
46.00000	20.00000	.90000	.06486	.46460	.16852	73.30180
47.00000	22.22222	.90000	.07289	.48823	.29594	73.79003
48.00000	23.88889	.90000	.07946	.49347	.40224	74.28350
49.00000	26.66667	.90000	.09148	.52293	.62704	74.80643

GERMINATION TIME EQUALS 49 HOURS

Output Data—Continued

TIME	TEMP	DE	ELONGATION	KNL	EMAXT	DTIME	EMPRCENT
50	83	.003	.003	.0070046300	8.28	.00797	0.00
51	84	.003	.006	.0069553809	8.44	.01643	0.00
52	84	.003	.009	.0069553809	8.44	.02488	0.00
53	82	.003	.013	.0070538790	8.13	.03240	0.00
54	81	.004	.016	.0071031280	7.98	.03952	0.00
55	78	.003	.020	.0067112792	7.70	.04561	0.00
56	74	.003	.023	.0058290835	7.47	.05073	0.00
57	72	.003	.025	.0053879856	7.35	.05547	0.00
58	71	.003	.028	.0051674367	7.29	.06004	0.00
59	69	.003	.031	.0050086883	6.76	.06330	0.00
60	67	.002	.033	.0051322893	5.82	.06567	0.00
61	67	.002	.036	.0051322893	5.82	.06804	0.00
62	65	.002	.038	.0052558904	4.87	.07022	0.00
63	63	.002	.040	.0053794914	3.93	.07234	0.00
64	63	.002	.041	.0053794914	3.93	.07446	0.00
65	61	.001	.043	.0055030924	2.99	.07656	0.00
66	60	.001	.044	.0055648930	2.52	.07866	0.00
67	60	.001	.045	.0055648930	2.52	.08076	0.00
68	62	.002	.047	.0054412919	3.46	.08286	0.00
69	63	.002	.049	.0053794914	3.93	.08498	0.00
70	67	.003	.052	.0051322893	5.82	.08735	0.00
71	71	.004	.056	.0051674367	7.29	.09192	0.00
72	74	.005	.060	.0058290835	7.47	.09704	0.00
73	76	.005	.066	.0062701813	7.59	.10261	0.00
74	79	.006	.072	.0069318281	7.76	.10901	0.00
75	80	.007	.078	.0071523771	7.82	.11575	0.00
76	80	.007	.085	.0071523771	7.82	.12249	0.00
77	79	.007	.093	.0069318281	7.76	.12890	0.00
78	78	.007	.100	.0067112792	7.70	.13500	0.00
79	76	.007	.107	.0062701813	7.59	.14056	0.00
80	74	.007	.114	.0058290835	7.47	.14568	0.00
81	72	.006	.120	.0053879856	7.35	.15042	0.00
82	70	.006	.126	.0049468878	7.23	.15600	0.00
83	68	.005	.131	.0050704888	6.29	.15863	0.00
84	67	.005	.136	.0051322893	5.82	.16100	0.00
85	66	.005	.141	.0051940898	5.34	.16325	0.00
86	64	.004	.146	.0053176909	4.40	.16539	0.00
87	64	.004	.150	.0053176909	4.40	.16753	0.00
88	62	.004	.154	.0054412919	3.46	.16964	0.00
89	61	.003	.157	.0055030924	2.99	.17174	0.00
90	61	.003	.160	.0055030924	2.99	.17384	0.00
91	61	.003	.163	.0055030924	2.99	.17594	0.00
92	62	.004	.167	.0054412919	3.46	.17805	0.00
93	65	.005	.172	.0052558904	4.87	.18022	0.00
94	68	.007	.179	.0050704888	6.29	.18286	0.00
95	74	.010	.189	.0058290835	7.47	.18798	0.00
96	76	.011	.200	.0062701813	7.59	.19354	0.00
97	80	.014	.213	.0071523771	7.82	.20028	0.00
98	82	.015	.228	.0070538790	8.13	.20781	0.00
99	83	.016	.243	.0070046300	8.28	.21578	0.00
100	83	.016	.260	.0070046300	8.28	.22375	0.00
101	82	.017	.277	.0070538790	8.13	.23127	0.00
102	81	.018	.295	.0071031280	7.98	.23838	0.00
103	78	.017	.312	.0067112792	7.70	.24448	0.00

Output Data—Continued

104	76	.016	.328	.0062701813	7.59	.25004	0.0
105	74	.016	.304	.0058290835	7.47	.25516	0.0
106	73	.015	.359	.0056085346	7.41	.26008	0.0
107	71	.015	.374	.0051674367	7.29	.26465	0.0
108	70	.014	.388	.0049468878	7.23	.27023	0.0
109	69	.014	.402	.0050086883	6.76	.27309	0.0
110	68	.013	.415	.0050704888	6.29	.27613	0.0
111	67	.013	.428	.0051322893	5.82	.27850	0.0
112	66	.012	.440	.0051940898	5.34	.28074	0.0
113	65	.011	.452	.0052558904	4.87	.28292	0.0
114	64	.010	.462	.0053176909	4.40	.28506	0.0
115	63	.009	.471	.0053794914	3.93	.28718	0.0
116	62	.011	.482	.0053176909	4.40	.28932	0.0
117	65	.012	.494	.0052558904	4.87	.29150	0.0
118	68	.016	.510	.0050704888	6.29	.29413	0.0
119	71	.019	.530	.0051674367	7.29	.29870	0.0
120	74	.023	.553	.0058290835	7.47	.30382	0.0
121	76	.026	.579	.0062701813	7.59	.30938	0.0
122	79	.031	.610	.0069318281	7.76	.31579	0.0
123	80	.034	.644	.0071384490	7.81	.32251	0.0
124	81	.036	.680	.0070717216	7.96	.32957	0.0
125	80	.037	.716	.0071105928	7.80	.33625	0.0
126	79	.037	.753	.0068811775	7.73	.34258	0.0
127	77	.035	.788	.0064400712	7.60	.34832	0.0
128	75	.033	.822	.0060040266	7.47	.35357	0.0
129	73	.031	.853	.0055730436	7.33	.35841	0.0
130	72	.031	.884	.0053575479	7.26	.36306	0.0
131	71	.030	.914	.0051445830	7.19	.36753	0.0
132	70	.029	.943	.0049341490	7.11	.37317	0.0
133	69	.028	.971	.0050118455	6.64	.37646	0.0
134	68	.027	.998	.0050926638	6.16	.37911	0.0
135	67	.025	1.023	.0051766038	5.69	.38150	0.0
136	66	.023	1.047	.0052636657	5.22	.38375	0.0
137	65	.021	1.068	.0053538493	4.75	.38595	0.0
138	65	.022	1.090	.0053603799	4.74	.38814	0.0
139	65	.022	1.112	.0053669105	4.74	.39033	0.0
140	66	.025	1.137	.0052835445	5.19	.39259	0.0
141	68	.030	1.166	.0051055992	6.09	.39525	0.0
142	70	.035	1.201	.0049214103	7.00	.40096	0.0
143	74	.043	1.244	.0056960368	7.25	.40582	0.0
144	77	.050	1.293	.0062678303	7.44	.41131	0.0
145	79	.056	1.349	.0066405871	7.57	.41730	0.0
146	80	.059	1.408	.0068181032	7.63	.42357	0.0
147	80	.061	1.470	.0068041752	7.62	.42982	0.0
148	80	.063	1.532	.0067902471	7.61	.43606	0.0
149	79	.062	1.595	.0065899364	7.54	.44198	0.0
150	78	.061	1.656	.0063921566	7.46	.44763	0.0
151	77	.060	1.716	.0061969076	7.38	.45302	0.0
152	76	.059	1.774	.0060041895	7.30	.45818	0.0
153	75	.057	1.831	.0058140022	7.22	.46312	0.0
154	74	.056	1.887	.0056263457	7.14	.46786	0.0
155	73	.054	1.941	.0054412201	7.06	.47243	0.0
156	72	.052	1.993	.0052586253	6.98	.47682	0.0
157	71	.050	2.044	.0050785614	6.89	.48105	0.0

Output Data—Continued

158	69	.045	2.088	.0050190210	6.36	.48439	0.0
159	68	.041	2.130	.0051388616	5.91	.48708	0.0
160	66	.033	2.163	.0053829385	5.01	.48936	0.0
161	64	.024	2.187	.0056332590	4.11	.49154	0.0
162	63	.018	2.205	.0057655868	3.66	.49369	0.0
163	63	.018	2.223	.0057752392	3.66	.49585	0.0
164	64	.023	2.247	.0056575335	4.09	.49803	0.0
165	66	.033	2.280	.0054077870	4.97	.50032	0.0
166	68	.042	2.322	.0051517970	5.84	.50301	0.0
167	72	.055	2.378	.0052167735	6.85	.50731	0.0
168	75	.064	2.442	.0056977350	7.07	.51208	0.0
169	77	.071	2.513	.0060216647	7.22	.51725	0.0
170	79	.078	2.591	.0063455941	7.37	.52288	0.0
171	80	.083	2.674	.0065075587	7.45	.52878	.2
172	80	.084	2.757	.0065075587	7.45	.53468	1.0
173	79	.081	2.839	.0063455941	7.37	.54031	1.9
174	78	.079	2.917	.0061836294	7.30	.54571	2.7
175	76	.073	2.990	.0058597001	7.14	.55067	3.6
176	74	.067	3.056	.0055357707	6.99	.55527	4.4
177	73	.064	3.120	.0053738061	6.92	.55970	5.2
178	71	.058	3.178	.0050498768	6.76	.56384	6.0
179	69	.049	3.227	.0050219762	6.25	.56721	6.7
180	68	.043	3.269	.0051560404	5.81	.56990	7.3
181	66	.029	3.299	.0054241686	4.94	.57220	7.9
182	65	.021	3.320	.0055582328	4.50	.57442	8.3
183	64	.013	3.333	.0056922969	4.06	.57660	8.6
184	63	.005	3.338	.0058263610	3.62	.57876	8.8
185	62	0.000	3.338	.0059604252	3.18	.58091	8.8
186	61	0.000	3.338	.0060944893	2.75	.58305	8.8
187	61	0.000	3.338	.0060944893	2.75	.58520	8.8
188	63	.005	3.343	.0058263610	3.62	.58736	8.8
189	66	.028	3.371	.0054241686	4.94	.58965	8.9
190	67	.035	3.406	.0052901045	5.37	.59207	9.3
191	71	.058	3.464	.0050498768	6.76	.59621	9.8
192	76	.075	3.539	.0058597001	7.14	.60118	10.6
193	79	.086	3.625	.0063455941	7.37	.60681	11.6
194	81	.092	3.717	.0063761276	7.60	.61300	12.9
195	82	.094	3.810	.0062446964	7.74	.61950	14.3
196	80	.090	3.901	.0065075587	7.45	.62540	15.7
197	79	.086	3.986	.0063455941	7.37	.63103	17.1
198	78	.081	4.068	.0061836294	7.30	.63642	18.5
199	77	.077	4.145	.0060216647	7.22	.64159	19.8
200	74	.065	4.210	.0055357707	6.99	.64619	21.1
201	72	.057	4.267	.0052118414	6.84	.65047	22.2
202	70	.050	4.317	.0048879121	6.69	.65636	23.2
203	70	.050	4.366	.0048879121	6.69	.66224	24.0
204	68	.032	4.398	.0051560404	5.81	.66494	24.8
205	67	.022	4.420	.0052901045	5.37	.66737	25.4
206	65	.001	4.421	.0055582328	4.50	.66959	25.8
207	65	.001	4.421	.0055582328	4.50	.67181	25.8
208	64	0.000	4.421	.0056922969	4.06	.67399	25.8
209	64	0.000	4.421	.0056922969	4.06	.67617	25.8
210	63	0.000	4.421	.0058263610	3.62	.67834	25.8
211	63	0.000	4.421	.0058263610	3.62	.68050	25.8

PART 4.—SIMCOT II: A SIMULATION OF COTTON GROWTH AND YIELD¹

By J. M. McKinion, D. N. Baker, J. D. Hesketh, and James W. Jones²

INTRODUCTION

On the following pages we document a segment of our work in the simulation of cotton growth and yield and provide operating instructions for the resultant computer model SIMCOT II.

This work began as an effort to assess the theoretical yield limits in commercial upland cottons through the calculations of photosynthate production and respiratory losses (2, 3)³ and evolved into an analysis of the physiological reasons for the failure of these cottons to attain this potential. Stapleton (7) and Stapleton and Meyers (9) had called for the application of systems methodology to this problem for the purpose of design and optimization of machinery arrays, and this work resulted in the first digital-computer simulation of cotton growth (8). Similar work was begun independently and at about the same time by A. B. Hearn (4) in Uganda.⁴

SIMCOT II is a direct descendent of SIMCOT, which was developed by Duncan (5). The overall approach is the same: the calculation of daily production and distribution of photosynthate. The model continues the same philosophy of fruiting, the triggering of abscission of fruit,

and delays in node formation in response to physiological stress in the form of carbohydrate shortage, and it continues to limit above-ground vegetative growth relative to root growth in response to moisture stress. Development is still programed in physiological time (a function of temperature).

There are, however, a number of fundamental changes. A plant-map subroutine has been added, which keeps track of the age, weight, and nutritional status of fruit at every node. This provides an interface of insect damage routines. A nitrogen-balance subroutine has been added. Light interception is based on plant height rather than leaf-area index. Height is a useful index of the overall foliage display and is not density dependent as is leaf-area index.

The systems analysis has resulted in other basic changes. We have found that carbohydrate reserves are all available on a temporary basis and (now) may approximate 30% of the dry leaf weight. We have found that only squares (about 12 days old) are abscised in response to carbohydrate stress and only squares within a few days of bloom and very small bolls are abscised in response to nitrogen stress. The most fundamental advance of SIMCOT II lies in the abolition of the "standard plant" as a means of calculating potential growth. The logic replacing the standard plant was essential to the simulation and incorporates the notion of senescence of stem and root tissue. This will be described in detail elsewhere. These changes represent new knowledge about the physiology of cotton, which could not have been obtained through classical reductionist experimental research.

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³ Italic numbers in parentheses refer to items in "Literature Cited," p. 82.

⁴ Personal communication, 1970.

VALIDATION

SIMCOT II is essentially a carbohydrate balance. Beginning with emergence, light interception is calculated daily from plant height. From this, photosynthesis is calculated for a unit of ground area. Then, light respiration, maintenance respiration, and growth respiration are calculated and subtracted from photosynthesis to give a net increment of carbohydrate available per plant for growth on that day. Daytime and nighttime increments of growth of roots, stems, leaves, and fruit are calculated separately. The decision as to whether or not to grow leaf and stem tissue is based on estimated plant water stress. All potential growth is based on temperature.

Leaf weights were obtained weekly from large samples of plants grown in State College, Miss., in 1969. From these data a table of daily weight increments was constructed. A drought early in 1969 caused abnormally small leaves. Therefore, to obtain the potential (well-watered) leaf increments needed by SIMCOT II, we multiplied the 1969 data by a factor (LEFADD) to obtain reasonable leaf weights in the simulations (table 4-1). The system's temporary carbohydrate storage capacity is equal to 30 % of the leaf weight. Maximum carryover time is 1 day. Leaf senescence is simulated by subtracting from the leaf weight the increment added 70 days previously.

TABLE 4-1.—*Factors to be used to adjust leaf area production*

Plant population	LAFADD
20,498	1.75
41,000	1.85
80,000	1.00
125,000	1.00

Stem growth was developed as follows: Stem weights from the 1969 weekly plant samples were used to provide potential stem weight increments for the first 42 days of growth. From day 10 to day 42 the growth data fit the following expression:

$$\Delta W = 0.2 + 0.06 (STMWT), \quad (4-1)$$

where ΔW is the potential stem growth and $STMWT$ is the accumulated stem weight in grams.

After 42 days, potential stem growth was obtained from the expression

$$\Delta W = 0.2 + 0.06 (STMWT - I_{24}), \quad (4-2)$$

where ΔW is change in weight in grams per day, $STMWT$ is stem weight in grams, and I_{24} is stem growth 24 days earlier.

Potential root growth is computed in the same way as stem growth, except that it is only 10 % as large and is not affected by moisture stress.

The growth of each fruit is kept track of individually in two-dimensional matrices (one axis representing the main-stem node number and the other axis, the fruiting-branch node number). Temperature effects are accounted for in computing the date of initiation, bloom, and boll opening. Potential weight increments for each fruit are taken from a table of weight increments versus fruit age. The data in that table are taken from fruit grown with an abundant supply of carbohydrates.

The carbohydrate requirements for potential growth of all organs is summed and then divided into the net carbohydrate available. All organ weights are incremented by that fractional amount of their respective potential growth. If the ratio is greater than 1, the excess is stored in temporary reserve. Any excess beyond 30 % of leaf weight is assigned to the stem weight and root weight.

When the first square is 6 days from bloom, a term called BOLINC is computed as the ratio of actual to potential fruit growth. If BOLINC is less than 0.85, stresses are said to exist, which cause the squares to abscise and delay the formation of new nodes, as shown in the flow charts below. All fruit within the appropriate age bracket are shed 8 days from the occurrence of the stress.

The Crops

One crop used to verify our simulation was grown in State College, Miss., in 1961 by Bruce and Römken (4). Briefly, the treatment they used was as follows: The cotton variety was a doubled haploid, 'Deltapine M8948'. Before planting, fertilizer was broadcast at the rates of 75 lb N, 44 lb P, and 83 lb K per acre. Three sidedressings of 75 lb N each were applied at 4-week intervals after planting. The plants emerged on

May 9 and were uniformly spaced in 91-cm rows at 20,498 plants per acre. The soil was irrigated to field capacity whenever tensiometer readings reached 0.3 bar. Insect control was nearly complete. Ten plants were mapped weekly, and the status of the fruit at each node was recorded. We summarized those data to produce weekly maps of an average or representative plant.

Another crop grown commercially and described by Jenkins et al. (6) was planted in 101.6-cm rows at 41,000 plants per acre in 1972 in Copiah County, Miss. At planting, fertilizer was banded at the rates of 20 lb N, 17.5 lb P, and 33 lb K per acre. Some moisture stresses were allowed to occur during the season. Again, insect control was very good. Square and boll counts were made weekly on 30 meters of row.

Results

More detail on these validation experiments can be found in papers by Baker et al. (1) and by Jenkins et al. (6). Main-stem node number and fruiting site production in the 1961 crop are presented in figure 4-1. The data describe a typical sigmoid growth curve. Growth is exponential at first, becoming linear as maintenance respiration becomes significant and leveling off somewhat as carbohydrate shortages brought on by the high demands for boll growth delay the formation of new nodes.

Real and simulated fruit production is presented in figure 4-2. To track square production this well early in the season, the model was programmed to abscise pinhead squares (1 day old) in response to solar radiation levels above 700 ly/day. The carbohydrate stresses are mild at first, becoming more severe as the season progresses until some of the bolls mature and open around September 14. Day-to-day variation in the stress was caused by variations in the weather (mainly solar radiation).

Two points should be mentioned here concerning the development of this simulation: First, in order to track properly the early onset of stresses (as evidenced by square shedding and a leveling off of site production in the real system), we had to acknowledge the existence of a large vegetative sink. Numerous mechanisms were tried and coefficients used before we developed equation 4-2. This equation states that potential stem growth is proportional to the weight of the

vegetative sink and that tissue no longer contributes to sink strength (capable of cell wall thickening) after 24 days. The second point is that all earlier (unvalidated) versions of SIMCOT were based on the assumption that the fruit is most likely to abscise in response to stress at bloom (about 26 days) and that progressively greater stresses would bracket that, with wider and wider age envelopes of fruit abscised. To accomplish this simulation, we were forced to abandon that assumption in favor of abscission at an earlier age (12 days). Depending on stress intensity then, the present model marks squares 8 to 13 days old, and they are 16 to 21 days old at abscission. Abscission of any bolls ruins the simulation. We believe, therefore, that boll shed results from nitrogen stress.

Figure 4-2 shows apparent regrowth (squares) on the 140th day. We had stopped mapping the real plants before that time, so no data are available to verify this. The model predicts regrowth because the maturing of some bolls made additional photosynthate available for development of new meristems.

The model crop reached a maximum leaf-area index (LAI) of 4.2 on day 95 (August 12) and yielded 2.98 bales per acre.

The computer output for the 1972 Copiah County crop is presented under "Example Runs." This simulation was obtained with the same program as above. The real plants, on the average, and the model plants both produced seven bolls for a yield of 1.68 bales per acre. Again, fruiting was simulated almost perfectly. This crop abscised eight young bolls in response to nitrogen stresses.

We feel that this is a minimal validation effort. SIMCOT II obviously simulates Delta cottons well in the Midsouth. We expect that it will do well in the Southeast and in much of Texas. At present certain modifications are necessary for use on the Texas High Plains and in dryland areas. Generally, these modifications are simple to make and should be considered in the following order:

1. Make sure that the algorithms in PNET for computing plant height and light interception are performing properly for your crop. This has required modification for "okra leafed" cottons and for High Plains varieties.

2. Be sure first square occurs on the proper date. For the High Plains varieties a different

number of physiological days to first square must be used.

3. The WATERZ subroutine is simple. Under dryland conditions modifications in selecting plant water stress levels may be needed.

Weaknesses in the simulation in these areas have pointed to potentially productive future experiments. As new information becomes available, we (and we hope others) will make appropriate modifications in the model.

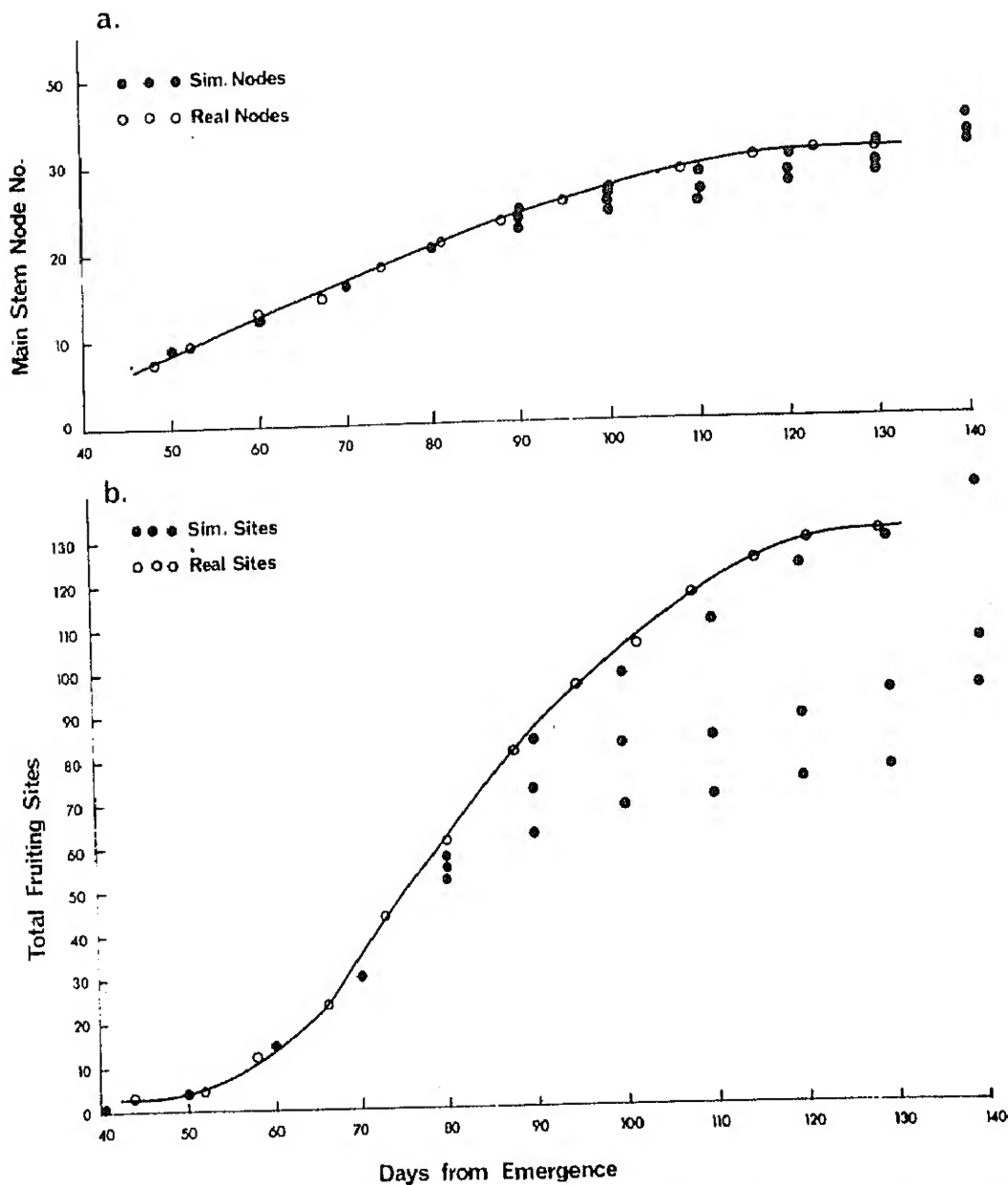


FIGURE 4-1.—A season's time course of main-stem node and fruiting site development. Open circles and lines trace the real crop planted at 20,498 plants per acre. Upper, middle, and lower solid circles represent model predictions for 20,498, 41,000, and 80,000 plants per acre, respectively.

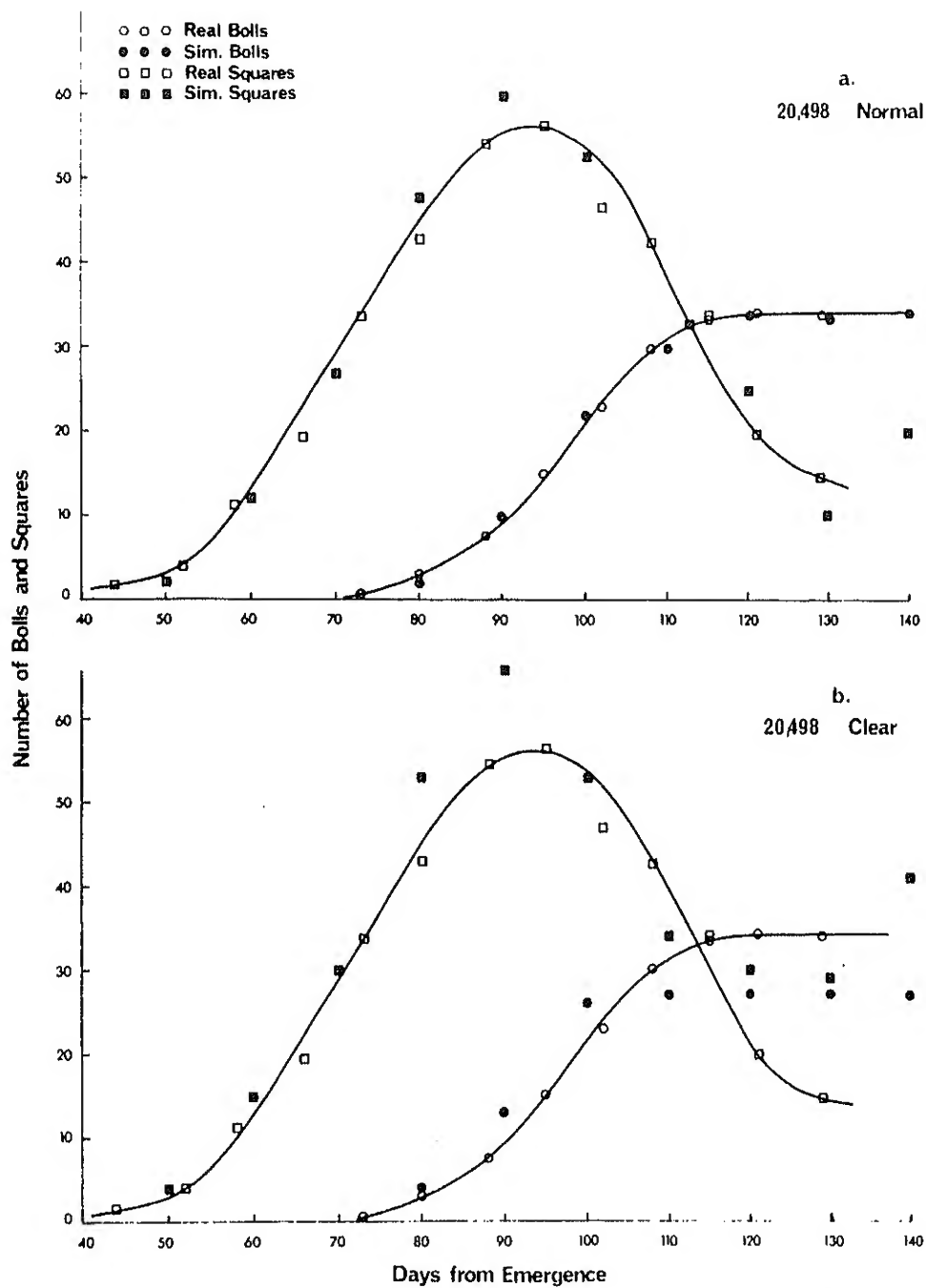
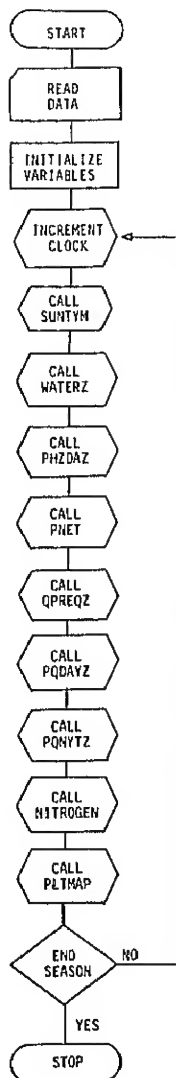


FIGURE 4-2.—Seasonal time course of fruiting for the real crop and for simulated crops at 20,498 plants per acre under normal and all clear skies.

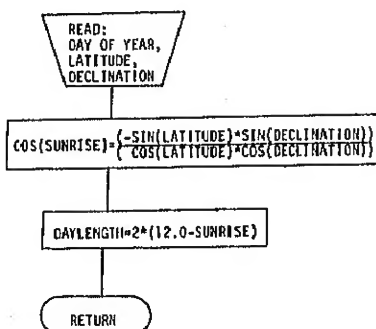
DESCRIPTION AND FLOW CHARTS

MAIN PROGRAM



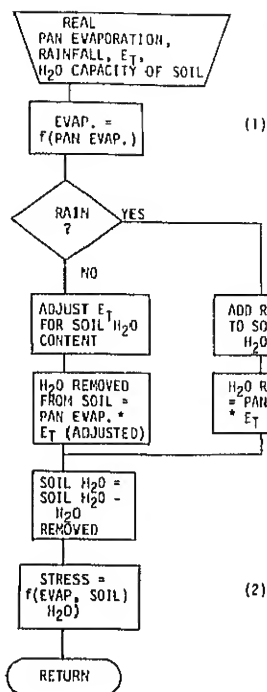
THE MAIN PROGRAM INITIALIZES ALL VARIABLES, READS IN WEATHER DATA, PLANT MANAGEMENT DATA AND CALLS ALL SUBROUTINES TO GROW THE PLANT. AFTER THE PLANT HAS BEEN GROWN TO THE END OF THE SEASON, THE MAIN PROGRAM THEN PRINTS PERTINENT INFORMATION: SUCH AS, BALES PER ACRE, NUMBER OF OPEN BOLLS. THE USER CAN CAUSE THE PROGRAM TO LIST THE PLANT MAP AS OFTEN AS DESIRED OR NOT AT ALL. IF THE USER DESIRES, HE CAN ALSO MAKE CHANGES IN THE FRUIT MATRIX TO SIMULATE INSECT DAMAGE.

SUBROUTINE SUNTYM



THIS PROGRAM COMPUTES THE LENGTH OF THE DAY FOR ANY DAY OF THE YEAR.

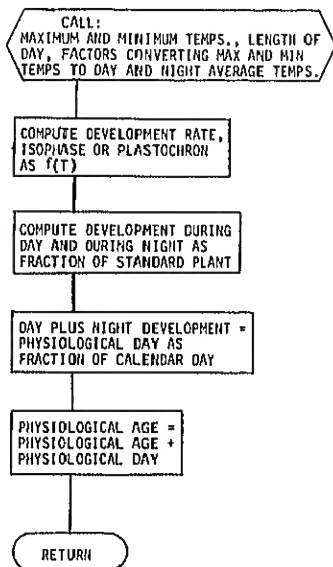
SUBROUTINE WATERZ



THIS PROGRAM ADJUSTS SOIL MOISTURE FOR EVAPORATION AND RAINFALL AND EVALUATES PLANT STRESS IN TERMS OF WATER REMAINING IN THE SOIL AND THE PAN EVAPORATION FOR THE DAY, ARBITRARILY. CLIMAT (JJ,4) IS RAINFALL AND CLIMAT (JJ,5) IS PAN EVAPORATION FOR THE JJTH DAY. RUNOFF (OR SOAKTHROUGH) IS CALCULATED. MOISTURE STRESS IS CALCULATED FROM THE COMBINATION OF SOIL WATER CONTENT AND EVAPORATIVE DEMAND AS MEASURED BY PAN EVAPORATION.

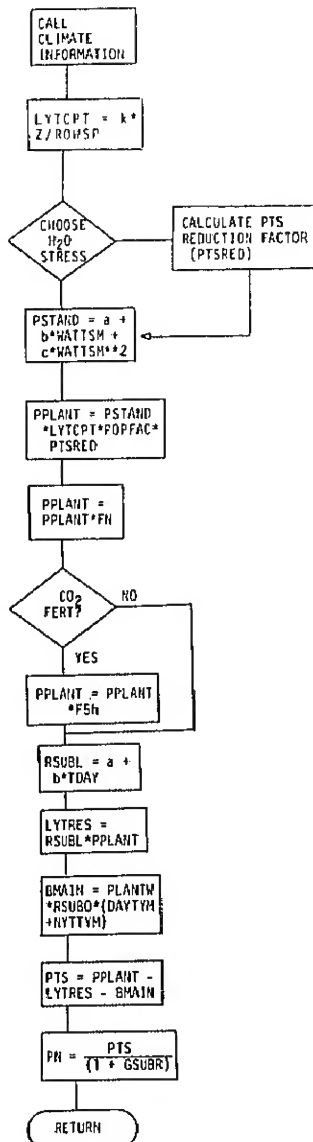
(1) AND (2) ARE ARBITRARY RELATIONSHIPS.

SUBROUTINE PHZOAZ



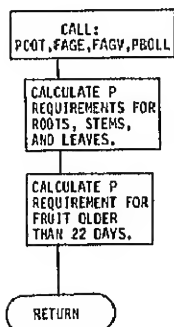
THIS PROGRAM CALCULATES THE LENGTH OF EACH PHYSIOLOGICAL DAY AND NIGHT BASED ON THE ESTIMATED AVERAGE TEMPERATURE OF EACH IN °C. One PHYSIOLOGICAL DAY IS A 24 HOUR PERIOD IN WHICH THE AVERAGE TEMPERATURE WAS 26°C. IF THE AVERAGE TEMPERATURE WAS LESS THAN 26°C, THEN WE HAVE A FRACTION OF A PHYSIOLOGICAL DAY. IF THE AVERAGE TEMPERATURE IS GREATER THAN 26°C, THEN WE HAVE A PHYSIOLOGICAL DAY PLUS A FRACTION.

SUBROUTINE PNET



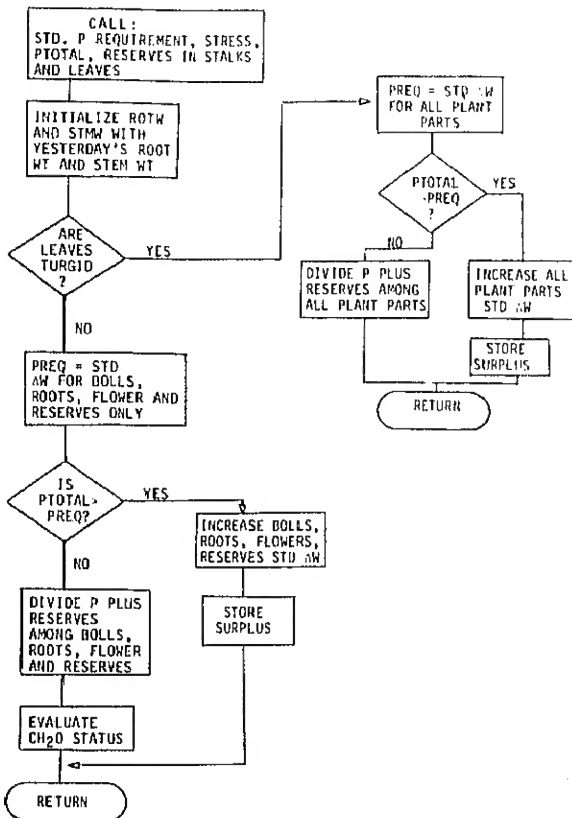
THIS SUBROUTINE CALCULATES THE DAY'S INCREMENT OF NET PHOTOSYNTHATE PRODUCTION PER PLANT. THE FRACTION OF INCIDENT LIGHT INTERCEPTED (LYTCPT) BY THE PLANT CANOPY IS COMPUTED FROM EMPIRICAL DATA BASED ON PLANT HEIGHT (Z). PTSRED IS THE FACTOR BY WHICH LEAF WILTING REDUCES THE RATE OF PHOTOSYNTHESIS. PSTAND IS POTENTIAL GROSS PHOTOSYNTHATE PRODUCTION BY THE PLANT CANOPY BASED ON DAILY TOTAL SOLAR RADIATION (WATTSM). THE POTENTIAL DAY'S GROSS PHOTOSYNTHATE PRODUCTION (PSTAND) IS REDUCED BY THE WATER STRESS FACTOR (PTSRED) AND BY LYTCPT AND FINALLY BY A PLANT POPULATION FACTOR (POPFAC) TO GIVE PHOTOSYNTHATE PRODUCTION ON A PER PLANT BASIS (PPLANT). THIS IS BASED ON EXPERIMENTS IN INTACT CANOPIES AT 300 PPM CO₂. PPLANT IS THEN ADJUSTED FOR AN AVERAGE DAILY CO₂ LEVEL ABOVE 300 IN FIELD AIR. A PROVISION IS MADE FOR FURTHER ADJUSTMENT TO ACCOUNT FOR THE EFFECTS OF CO₂ FERTILIZATION ASSUMING A RELEASE OF 200 LB/ACRE/HR FOR FIVE MIDDAY HOURS. LIGHT RESPIRATION (LYTRES) IS A FUNCTION OF TEMPERATURE AND PROPORTIONAL TO PHOTOSYNTHATE PRODUCTION. MAINTENANCE RESPIRATION IS PROPORTIONAL TO PLANT WEIGHT. GSUBR IS GROWTH RESPIRATION.

SUBROUTINE QPREQZ



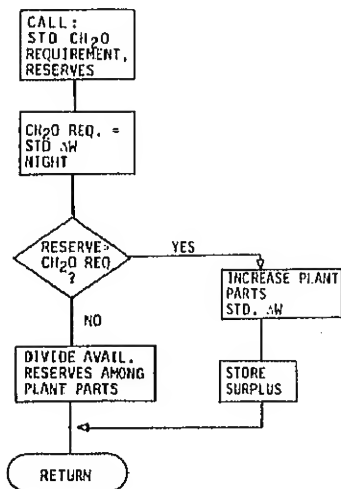
THIS SUBROUTINE CALCULATES THE REQUIRED PHOTOSYNTHATE FOR GROWTH OF EACH PLANT PART: ROOTS, STEMS, LEAVES, AND INDIVIDUAL FRUIT WHICH ARE OLDER THAN 22 DAYS.

SUBROUTINE PQDAYZ



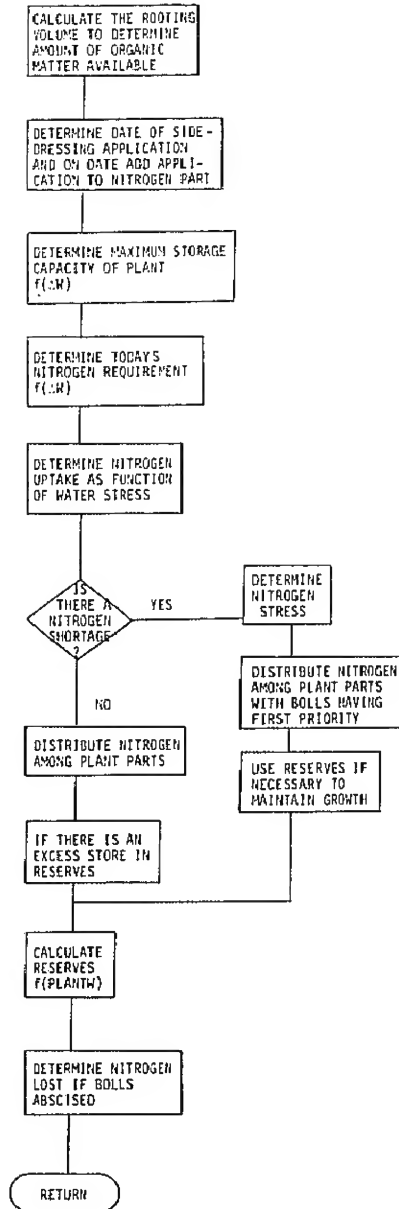
THIS PROGRAM COMPUTES THE PHOTOSYNTHATE USED FOR PLANT GROWTH FOR THE DAY. STMW AND ROTW ARE SET TO TODAY'S STEM AND ROOT WEIGHT BEFORE ANY GROWTH OCCURS. THESE TWO VARIABLES ARE THEN USED IN PLTHAP TO RETIRE STEM AND ROOT MATERIAL OLDER THAN 24 DAYS FROM THE RESPIRING BIOMAS. MAXIMUM CH₂O RESERVE SIZE EQUALS 30 PERCENT OF THE LEAF DRY WEIGHT. IT IS ALL AVAILABLE ON ANY GIVEN DAY. PTOTAL = PH + RESERVES. EXCESS PHOTOSYNTHATE BEYOND THAT NEEDED FOR GROWTH AND RESERVES IS ACCUMULATED AS DRY MATTER IN THE ROOTS.

SUBROUTINE PQNYTZ



THIS PROGRAM CALCULATES THE PHOTOSYNTHATE REQUIRED FOR PLANT PARTS FOR THE NIGHT AND COMPUTES THE WEIGHT GAINS EXCEPT FOR FRUIT. IT ALSO COMPUTES WHETHER BOLL SET WILL OCCUR BASED ON THE CALCULATED CARBOHYDRATE STRESS OR LACK OF IT. POLYNA IS THE VARIABLE USED TO DETERMINE BOLL SET AND IT GIVES A VALUE. SIGNALS THAT A BOLL MAY BE SET IF A BLOOM IS PRESENT.

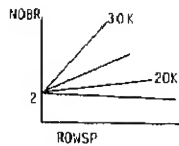
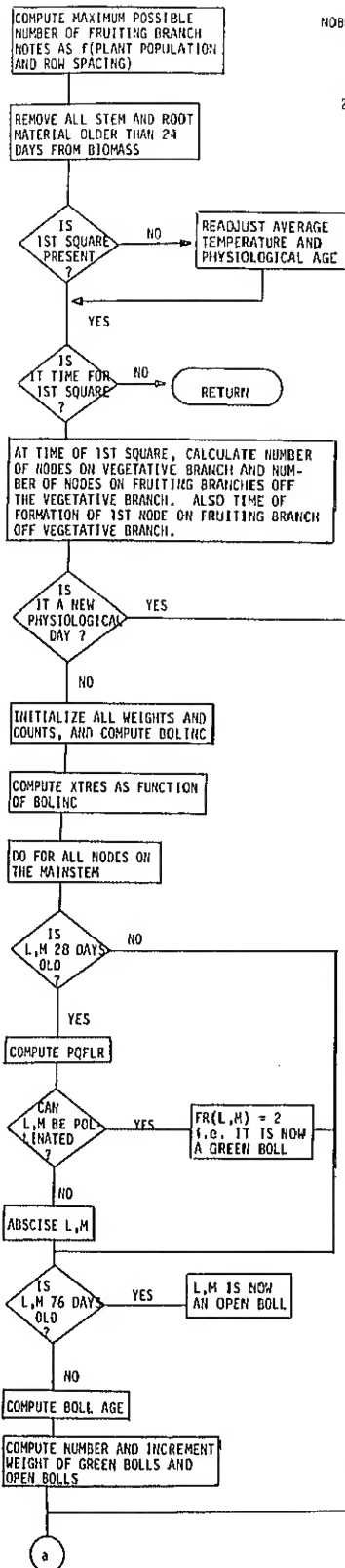
SUBROUTINE NITR



THE NITROGEN SUBROUTINE CALCULATES A NITROGEN BALANCE FOR THE PLANT. NITROGEN REQUIREMENTS FOR STEMS, ROOTS, AND LEAVES ARE CALCULATED AS A FUNCTION OF INCREASE OF WEIGHT OF THE GROWING TISSUES OF THOSE PLANT PARTS. THE SEED AND BURR REQUIREMENTS ARE CALCULATED AS A FUNCTION OF TOTAL FRUIT WEIGHT. NITROGEN UPTAKE IS CALCULATED ON A PLANT BASIS AS A FUNCTION OF WATER STRESS. THIS NITROGEN IS TAKEN FROM A NITROGEN POOL IN THE SOIL THAT CONSISTS OF RESIDUAL NITROGEN FROM THE PREVIOUS YEAR, NITROGEN FROM DECOMPOSITION OF ORGANIC MATTER, AND NITROGEN FROM PRE-EMERGENCE AND SIDE-DRESSING APPLICATIONS.

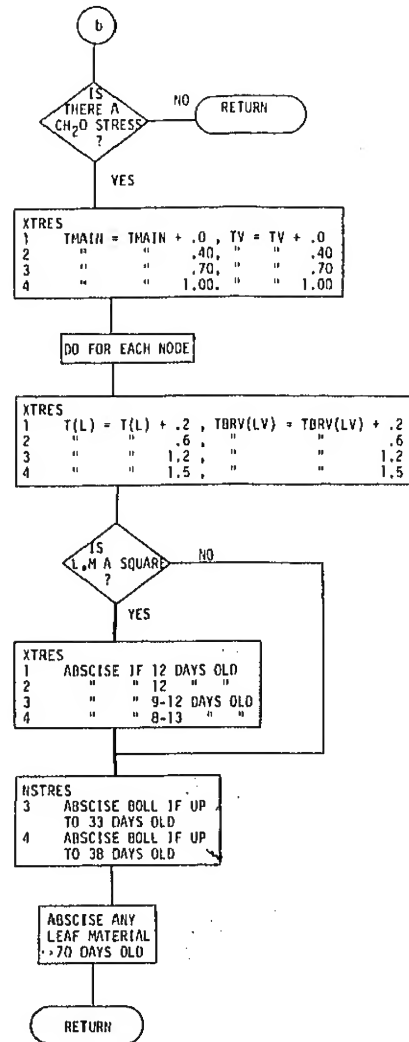
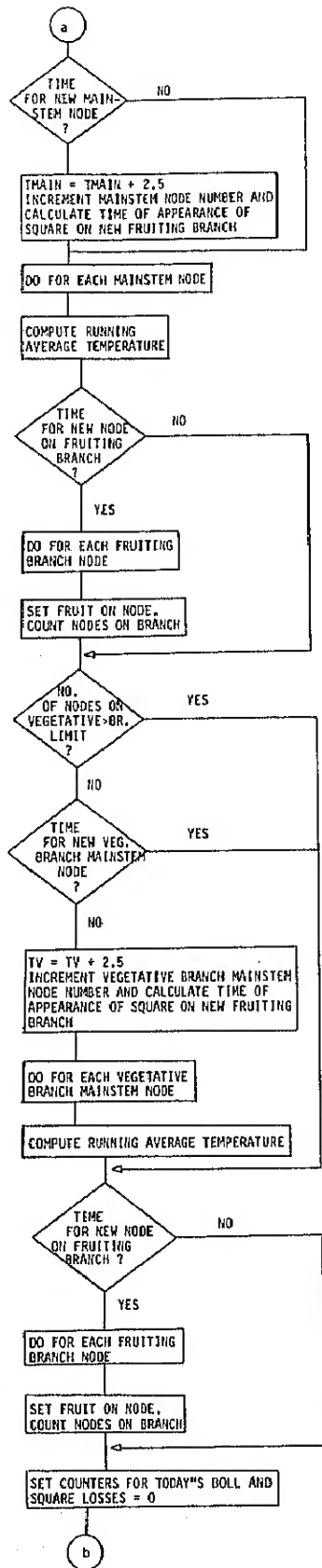
WHEN THE PLANT DEMAND EXCEEDS WHAT CAN BE TAKEN UP DAILY, A NITROGEN STRESS (NSTRES) IS DETERMINED FROM THE SEVERITY OF THE SHORTAGE. IF MORE NITROGEN IS TAKEN UP THAN CAN BE USED, THEN THIS EXCESS NITROGEN IS STORED IN LEAVES, STEMS, AND ROOTS AND THE RESERVE NITROGEN THAT THE PLANT CAN DRAW ON FOR GROWTH IS CALCULATED AS A FUNCTION OF TOTAL STEM, ROOT AND LEAF WEIGHT. THUS WHEN THE PLANT IS IN A SHORTAGE SITUATION IN WHICH THE DEMAND IS MORE THAN SUPPLY OF NITROGEN THAT CAN BE TAKEN UP FROM THE SOIL POOL OF NITROGEN BY THE ROOT SYSTEM, THE PLANT CAN DRAW ON THE RESERVE NITROGEN POOL WHICH CONSISTS OF NITROGEN STORED IN ROOTS, STEMS, AND LEAVES. THUS A COMPLETE NITROGEN BALANCE IS PERFORMED BY THIS SUBROUTINE.

SUBROUTINE PLTMAP



THIS PROGRAM INITIATES SQUARES, MAINSTEM NODES, FRUITING BRANCH INTERNODES, AND A SINGLE VEGETATIVE BRANCH. BOLINC IS COMPUTED BASED ON TODAY'S BOLL GROWTH DIVIDED BY THE POTENTIAL GROWTH. CARBOHYDRATE STRESS IS THEN COMPUTED FROM BOLINC. PINHEAD SQUARES ARE ABSCISED IF SOLAR RADIATION IS GREATER THAN 700 WATTS/M². DELAYS IN FORMING NEW MAINSTEM NODES AND FRUITING BRANCH INTERNODES ARE GENERATED IF THERE IS A CARBOHYDRATE STRESS. SQUARES OF AN AGE CENTERED AT 12 DAYS ARE ABSCISED IN RESPONSE TO CARBOHYDRATE STRESS ALSO.

SUBROUTINE PLTMAP (Continued)



DEFINITION OF TERMS

Main Program		GRCOTX	Weight of green bolls.
ADD	Factor used to adjust LAI for different plant populations.	GSUBR	Vegetative respiration.
AGE	Counter for real time.	HISTD	Factor used in controlling boll setting.
ALAIFC	Leaf area ratio (leaf area/leaf weight).	H2OCAP	Water capacity of soil in inches per one-tenth of rooting depth.
ATL(3)	Not used.	H2OREM	Water remaining in soil.
BALECT	Bales per acre.	H2OREX	Water remaining in soil.
BALEFC	Used in determining flowering rate based on plant population.	H2ORUN	Calculated runoff of rainfall.
BLOOM	Number of fruit lost due to bloom sticking.	I	Physiological time. Integer variable.
BOLINC(J)	Percentage of total boll demand, dry weight, added each day. J is time from emergence.	IOLD	Variable used in determining whether or not a new physiological day has occurred.
BOLLST	Number of bolls lost on a given day due to carbohydrate shortage.	ISTSQR	Trigger for subroutine PLTMAP. Time is physiological time to first square.
BOLRES	Boll respiration.	JB	Number used to select how often plant will be printed out. Used when LAST equals zero.
CLIMAT(J,I)	Same as KLYMAT, but used to store weather data that is used in growing season. Julian day changed to day from emergence.	JJ	Time from emergence.
CLIMXX	Variable used to reorder weather data based on days from emergence rather than Julian day.	JJK	Trigger used in selecting output format of the program. First day to be listed.
COSLAT	COS(LATUDE).	JNEXT	Trigger for output in answering question from computer terminal "Do you want plant printed out on day JJ?" Answer "Zero" for "Yes;" "1" for "No."
COTXX	Weight of mature bolls.	JPLDAY	Day of emergence.
CO2	Carbon dioxide fertilization trigger. Read in with weather data.	JSEASN	SEASON+2 Trigger to end simulation.
DAY	Physiological time. Real variable.	KCARDS	Number of days of weather to be read into KLYMAT by the computer.
DAYFAC	Factor used in calculating length of daytime physiological time.	KLYMAT(J,I)	Environmental input to program. J is maximum number of days, equal to 300. I refers to different environmental variables. 1 is solar radiation in langleys per day. 2 is maximum daily temperature in degrees Fahrenheit. 3 is minimum daily temperature in degrees Fahrenheit. 4 is rainfall in inches per day. 5 is pan evaporation in inches per day. 6 is Julian day number. 7 is a CO ₂ trigger.
DECL(365)	Variable used for calculating daily declination values.	LAI	Leaf-area index (DM ² /DM ²).
DECLIN(365)	Table of declinations read in.	LAST	Trigger used in modifying matrices for simulating insect damage of plant. Zero means no changes. 1 means changes in matrix.
DIFSUM	Not used.	LATUDE	Latitude of crop being simulated.
DMACRE	Number of square decimeters in 1 acre.	LEAFW	Previous day's leaf weight. Used in calculating senescence.
EFF	Factor for adjusting photosynthetic efficiency of plant.	LEFRNU	Exponent used to adjust growth rate of leaves. Equal to 1.
ESUBT(I)	Evapotranspiration of plant ESUBT. (I) has five values.	LEFSTF	Percentage of leaf weight that can be used to store excess carbohydrate.
EVAPFC	Maximum transpiration considering pan evaporation.	LEFWT	Active tissue weight of leaves. Range 0 through 70 days.
FAGE(L,M)	Fruitage matrix for main plant.	LOSTD	Standard controlling boll setting.
FAGV(LV,MV)	Age of fruit in days from initiation at proper LV, MV location, vegetation branch.		
FLOWER	Used in determining flowering rate based on plant population.		
FR(L,M)	Fruiting matrix for main plant.		
FRV(LV,MV)	Fruiting matrix where fruit code is stored. LV is vegetative branch main-stem node number. MV is fruiting branch off of vegetative branch node number. FRV(LV, MV) : 1 is square, 2 is green boll, 3 is mature boll, 4 is abscised fruit site, 5 is square designated to abscise, and 6 is boll designated to abscise.		

SINDCL
SUNRIZ

SIN (DCLVAL).
Time from solar noon to sunrise.

Subroutine WATERZ

EXIT Trigger indicating that H2OEXC is less than zero.
H2ODEF Soil water deficiency.
H2OEXC Excess soil water after deficit has been taken care of.
K Number of layers of soil WRT rooting depth.
KMOIST Variable used to calculate second subscript of XSTRES(EVAP, NSW).
NSW Subscript of array XSTRESS (EVAP, NSW).
PANVAP Pan evaporation in inches per day.
WATER Rainfall (irrigation).

Subroutine PHZDAZ

DAYT Daytime physiological time based on temperature and length of day.
DAYTYM Fractional physiological time of day.
MAXMIN Difference between maximum daily temperature and minimum daily temperature.
NYTT Nighttime physiological time based on temperature and length of night.
NYTTYM Fractional physiological time of night.
TAVG Average 24-hour temperature.

Subroutine PNET

BMAIN Photosynthate required to maintain present plant material.
LYTCPT Fraction of incident solar radiation intercepted as function of LAI.
LYTRES Light respiration.
PN Net photosynthate.
PPLANT Photosynthate produced per plant.
PSTAND Photosynthate produced by stand of plants as function of WATTSM.
PTS Photosynthate after light respiration and maintenance have been subtracted.
PTSRED Photosynthate reduction factor.
RSUBL Coefficient for light respiration.
WATTSM Solar radiation in watts per square meter.

Subroutine QPREQZ

F Not used.
LEFADD Factor used to adjust LAI for crops with different populations.
NAGE Age of fruit from initiation of square.
PQBOLD Boll photosynthate requirement for full growth during day.
PQBOLN Boll photosynthate requirement for full growth during night.
PQBOLX Total boll requirement for 24 hours.
PQLEFD Photosynthate required for full leaf growth during day.

PQLEFN Photosynthate required for full leaf growth during night.
PQRESN Requirement for rebuilding depleted reserves.
PQRTSD Photosynthate required for full root growth during day.
PQRTSN Photosynthate required for full root growth during night.
PQSTMD Photosynthate required for full stem growth during day.
PQSTMN Photosynthate required for full stem growth during night.
QLEF Not used. Equal to QUAN.
QRTS Not used. Equal to QUAN.
QSTM Not used. Equal to QUAN.
QUAN Constant to obtain proper proportioning of photosynthate.

Subroutine PQDAYZ

F Ratio of available photosynthate to that required.
ROTW Variable used to calculate root senescence.
STMW Variable used to calculate stem senescence.
TRESXX Maximum photosynthate that can be translocated during day.

Subroutine PQNYTZ

ABC Variable used to see if boll setting requirements are met.
PREQZ Photosynthate required for growth if roots are not grown.
STQN Same as PREQZ.
TSLMT Maximum photosynthate that can be stored in leaves.

Subroutine NITR

AD Actual root volume depth.
AL Actual root volume length.
APPL Sidedressing.
AW Actual root volume width.
BCON Burr concentration of nitrogen by weight.
BOLI Nitrogen requirement for today's boll growth.
BURMIN Maximum nitrogen requirement for today's burr growth.
BURR Maximum burr usage capacity for nitrogen.
BURRI Nitrogen requirement for today's burr growth.
CD Depth of maximum root volume per plant.
CL Length of maximum root volume per plant.
COTTON Total mature and green cotton weight.
CW Width of maximum root volume per plant.
DEFCIT Difference between boll growth requirement for nitrogen and nitrogen taken up from soil.

DREQN	Maximum capacity of plant for storage of nitrogen.
EFN	Efficiency of application of preemergence application and sidedressing (if any).
EXC	Amount of nitrogen taken up above needs of plant for growth.
GRGR	Amount of fruit growth on plant.
LCONC	Leaf concentration of nitrogen by weight.
LEFR	Maximum carbohydrate storage capacity of leaves.
LEFRI	Nitrogen requirement for today's leaf growth.
LEFRS	Reserve nitrogen stored in leaves.
NMAX(I)	Maximum nitrogen concentration possible in plant parts. I is used as follows: 1, seed; 3, burrs; 4, stems; 5, roots.
NMIN(I)	Minimum nitrogen concentrations possible in plant parts as defined for NMAX(I).
NPART	Actual nitrogen in plant parts. I is defined as NMAX(I).
NSTRES	Nitrogen stress factor for reduction of growth and abscission of fruit.
PERN	Organic nitrogen pool in soil.
POM	Percentage of organic matter.
R	Rainfall in inches.
RCON	Nitrogen concentration in roots by weight.
REQ1	Nitrogen requirement for today's plant growth.
RESN	Reserve nitrogen available in plants for growth of fruit.
ROTR	Maximum capacity of roots for nitrogen.
ROTRI	Nitrogen requirement for today's root growth.
ROTRS	Reserve nitrogen in roots available for fruit growth.
RTOT	Cumulative sum of nitrogen demanded by the plant.
SCON	Seed concentration of nitrogen by weight.
SEEDR	Maximum seed usage capacity for nitrogen.
SEEDRI	Nitrogen requirement for today's fruit growth.
STCON	Nitrogen concentration in stems by weight.
STMR	Maximum capacity of stems for nitrogen.
STMRI	Nitrogen requirement for today's stem growth.
STMRS	Reserve nitrogen in stems available for fruit growth.
SUPR	Factor used for partitioning nitrogen among plant parts.
SUPRI	Factor used in partitioning nitrogen among plant parts.
TEMN	Soil pool of available nitrogen.
TOTAL	Plant requirement for growth plus

USE	excess nitrogen (if any) taken up. Parameter indicating rate of depletion of reserves.
VPLT	Actual root volume.
VTOT	Maximum root volume per plant.
WCOTX	Yesterday's mature cotton weight.
WGRCOT	Yesterday's green cotton weight.
WLEF	Yesterday's leaf weight.
WROT	Yesterday's root weight.
WSTM	Yesterday's stem weight.
XN	Maximum amount of nitrogen plant can take up per day.
XNUP	Nitrogen uptake of plant.
XNUP1	Amount of nitrogen taken up by plant.

Subroutine PLTMAP

AVTEMP	Accumulated average temperature for first 31 physiological days.
DSQ	Day of squaring on main stem.
DSV	Day of squaring on vegetative branch.
ICNOD	Trigger for adding new node to main-stem fruiting branch.
INOD	Main-stem node on plant at which the first square will appear.
ISQ	Trigger for telling when first square is on plant.
IVNOD	Trigger for adding new node to vegetative fruiting branch.
JK	Matrices for determining when fruit will be abscised after triggering the abscission process.
JKV	
LEAFWT(JJ)	Variable used to senesce leaf material.
NOBR	Maximum number of nodes on a main-stem fruiting branch.
NTL	Trigger for adding squares to a fruiting branch, from the main stem.
NTLV	Trigger for adding squares to a fruiting branch for a vegetative branch.
NV	Number of nodes on vegetative main stem.
PQBOLD	Photosynthate available for today's boll growth.
PQBOLN	Photosynthate available for tonight's boll growth.
PQBOLX	Total required photosynthate for maximum boll growth for 24 hours.
ROOTW(JJ)	Variable used to senesce root material.
STEM(JJ)	Variable used to senesce stem material.
TAVL	Running average temperature of nodes on main stem.
TBRV	Time till next node on vegetative fruiting branch.
T(L)	Time till next node on main-stem fruiting branch.
TMAIN	Time till next node on main stem.
TMPV	Running average temperature of nodes on vegetative branch.

TV	Time till next node on vegetative main stem.	XM	Variable used in calculating maximum number of nodes on a main-stem fruiting branch, based on plant population.
WLOST	Total root and stem material senesced on this day.		

PROGRAM SETUP AND EXECUTION

SIMCOT II is written in FORTRAN IV level G and has been run on the IBM 370-155 system at Clemson University and on the UNIVAC 1106 at Mississippi State University. The IBM 370-155 uses 91 K bytes of storage, and run time with a typical 10-day mapping output is 55 seconds. Comparable figures for the Univac 1106 are 23 K words and 34 seconds. We normally employ disk files for program and data sets, and we usually operate from terminal. In converting to Univac or IBM equipment the arc cosine term in SUNTYM must be used appropriately.

SIMCOT II can be used for plant population studies with up to 80,000 plants per acre. An appropriate "LEFADD" factor from table 4-1 and the per-acre plant population must be supplied as indicated on line 288 of the sample data.

Carbon dioxide fertilization experiments can be made by inserting a 1 in the appropriate column of the climate data. This provides 500 p/m CO₂ in the upper part of the plant canopy during 6 midday hours (roughly equivalent to 200 lb CO₂/acre/hour).

Photosynthetic efficiency can be varied by appropriate change in PNEFF in line 288 of sample data.

Nitrogen fertility studies can be made with different planting applications (INITIALN=pounds N per acre on line 290 of the sample data set) or by sidedressing with appropriate levels of APPL in pounds N per acre on line 36 of NITR.

Row-spacing studies can be made by changing ROWSP on line 288 of the sample data.

Soil-moisture studies require appropriate values for inches of water holding capacity in the top 12 inches (SOIL CAP on line 288 of the sample data) and may require changes in lines 18-24 of WATERZ on lines 281 to 283 of the sample data to reflect the effect of various climates on plant water status. We have not yet attempted to validate over a range of moisture stress conditions for different soils.

Emergence date studies can be done by changing EMERGE on line 288 of the sample data.

PROGRAM LISTING

MCKIN+TF.K

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BLOCK DATA
COMMON /COM/FR, DAY, I, JJ, PCOT, ISTDQR
INTEGER FR(45,8)
DATA FR/360*0/
REAL PCOT(200,9)
DATA DAY/0./, ISTDQR/0/
END

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MCKIN+TF.A

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      DIMENSION PCOT(200,9),PBOLL(60),KLYMAT(300,7),XSTRES(
&7,5),WTBOLL(45,8),CLIMAT(300,7)
      DIMENSION SOILW(10),ESUBT(5),          WTBOLV(30,5)
      INTEGER TTL(20)
      DIMENSION DECL(365),DECLIN(365)
      DIMENSION ATL(4)
      COMMON /COM/FR, DAY, I, JJ, PCOT, ISTDQR
      COMMON /STMT,ROOTWT
      INTEGER FR(45,8)
      INTEGER SOLOST,BOLLST,BLOOM,FRVL
      INTEGER CHARX/'X'/,CHARS/'*'/,CHARN/'#'/,CHARI/'I'/,CHARO/'O'/
      INTEGER FRV(30,5)/150*0/,FAGV(30,5)/150*0/,PRTV(30,5)/150*' '/,
1PRIV(30,5)/150*' '/
      INTEGER XTRES/0/,CO2/0/
      INTEGER PAGE(45,8)/360*0/,POLYNA/0/
      INTEGER PRT(45,8)/360*' '/,PRI(45,8)/360*' '/
      REAL NMAX(5),NMIN(5),NPART(5)/5*0./,LCONC/0./
      REAL LEAFW
      REAL LEFWT,LO STD,LAI,          NYTFAC,          LEFSTF          NYTT
1YM,          LATUDE,MINUTS,MINFAC,KLYMAT,          NYTFAC,          LEFSTF          NYTT
      REAL WLOST(3)/3*0./,AGE/0./
      DATA WTBOLL/360*0./,HISTD/.1/,LOSTD/.2/,STRLMT/.71/,TRNSLF/.2/
      DATA WTBOLV/150*0./,DAYFAC/.55/,NYTFAC/.45/,EVAPFC/.75/,RSUBO/
      1.0032/,ALAIFC/1.2/,TOPRES/0./,RESUFC/.6/,RESADD/.8/,GSUBR/.375/,
      2LEFSTF/.3/,NMIN(1)/.02/,NMIN(2)/.04/,NMIN(3)/.006/,NMIN(4)/.009/,
      3NMAX(1)/.042/,NMAX(2)/.04/,NMAX(3)/.02/,NMAX(4)/.02/
      DATA ATL/'DAY','VS','BOL','INC'/
      DATA SUMLEF/0./,SUMSIM/0./,SUMRTS/0./,GRCOTX/0./,NUMGPN/0./,NUMGPN/
      10/,DIFSUN/0./,DMACRE/404700./,COTX/0./,TOPRES/0./,PAVAIL/0./,TRES
      2/0./,          POLYNA/0/,SOLOST/0/,BOLLST/0/,LAI/.0/,PLANTW/1./,
      3PRESX/.01/,PBOLX/1./,PRES/.01/,RTS/1./,PREQ/0./,NEWDAY/
      40/,IOLD/0./,H2ORUH/0./
      READ(5,1000)((PCOT(K,J),J=1,9),K=1,41)
      1000 FORMAT(9F5.0)
      READ(5,1005)(PBOLL(J),J=1,60)
      1005 FORMAT(16F5.0)
      READ(5,1003)TTL
      1003 FORMAT(20A4)
      READ(5,1001)KCARDS
      1001 FORMAT(I10)
      READ(5,1010)((KLYMAT(K,J),J=1,7),K=1,KCARDS)
      1010 FORMAT(7F10.0)
      READ(5,1025)(DECLIN(J),J=1,365)
      1025 FORMAT(16F5.2)
      DO 2222 J=2,365
      2222 IF(ABS(DECLIN(J)).LT.0.5)DECLIN(J)=DECLIN(J-1)
      READ(5,1015)((XSTRES(J,K),K=1,5),J=1,7)
      1015 FORMAT(15F5.0)
      DO 786 J=42,200
      PCOT(J,1)=.08
      PCOT(J,2)=.0
      PCOT(J,3)=.80
      PCOT(J,4)=0.
      PCOT(J,5)=.60
      PCOT(J,6)=.0
      PCOT(J,7)=PCOT(41,7)
      PCOT(J,8)=0.
      786 PCOT(J,9)=15.00

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PROGRAM LISTING—Continued

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C DESCRIPTIONS OF THE ENVIRONMENT: LATITUDE, LENGTH OF SEASON, WATER
C CAPACITY OF THE SOIL IN INCHES PER TENTH OF THE ROOTING DEPTH
6 READ(5,1020)LATUDE, SEASON, H2OCAP, EMERGE, ROWSP, ADD, EFF, POPPLT
C MANAGEMENT OF THE CR-F: PLANTING DAY -& THE YEAR, PLANTS PER ACRE
C ROW SPACING, CENTIMETERS
2 READ(5,1020)POM, EFN, TEMN, RESIDN
1020 FORMAT(8F10.0)
TEMN=(TEMN+EFN/POPPLT)*453.6+RESIDN*453.6/POPPLT
READ(5,7055)JJK, LAST, JB
7055 FORMAT(3I5)
FLOWER=30000/POPPLT
BALEFC=.0000014*POPPLT
WS=0
WR=0
WL=0
MINFAC=.0002909
JSEASN=SEASON+2.
MATURE=SEASON+1.
NGREEN=SEASON-2.
RADFAC=.0174533
LATUDE=LATUDE*RADFAC
JPLDAY=EMERGE
SINLAT=SIN(LATUDE)
COSLAT=COS(LATUDE)
DO 8 J=1,365
K=DECLIN(J)
DEGRES=K
MINUTS=DECLIN(J)-DEGRES
8 DECL(J)=DEGRES*RADFAC+MINUTS*MINFAC*100.
K=1
DO 21 J=1,KCARDS
CLIMXX=KLYMAT(J,6)-EMERGE
IF(CLIMXX.LE.0.)GO TO 21
CLIMAT(K,7)=KLYMAT(J,7)
CLIMAT(K,6)=KLYMAT(J,6)
CLIMAT(K,5)=KLYMAT(J,5)
CLIMAT(K,4)=KLYMAT(J,4)
CLIMAT(K,3)=(KLYMAT(J,3)-32.)*5./9.
CLIMAT(K,2)=(KLYMAT(J,2)-32.)*5./9.
CLIMAT(K,1)=KLYMAT(J,1)
K=K+1
21 CONTINUE
ESUBT(1)=EVAPFC*.5
ESUBT(2)=EVAPFC*.7
ESUBT(3)=EVAPFC*.8
ESUBT(4)=EVAPFC*.9
ESUBT(5)=EVAPFC
POPFAC=DMACRE/POPPLT
ROOTWT=PCOT(1,1)
STMWT =PCOT(1,3)
LEFWT=PCOT(1,5)
I=1
WRITE(6,1004)TTL
1004 FORMAT(' ',20A4)
DO 145 J=1,10
145 SOILW(J)=H2OCAP
TIME=1.
DO 998 JJ=1,JSEASN
JNEXT=0
AGE=AGE+TIME
IF(AGE.GT.SEASON)GO TO 998
H2OREM=0.
RFALL=CLIMAT(JJ,4)
CALL SUNTYM(JPLDAY, DECL, DAYLNC, SINLAT, COSLAT)
CALL WATER2(CLIMAT, H2OCAP, H2ORUN, STRESS, XSTRES, SOILW, ESUBT, H2ODEF)
CALL PH2OAZ(CLIMAT, DAYFAC, NYTFAC, DAYLNC, TOLD, TDAY, THYT, DAYTYM,
INITYTM, TFACD, TFACH, NEWDAY, TAVG)
CALL PHET(CLA1, CLIMAT, POPFAC, PLANTW, DAYTYM, INITYTM, RSUBO, PN, STRESS,
1TDAY, LYRES, CSUBR, CO2, EFF, ROWSP, NMIN, LCONC)
CALL APREQZ(POLEFD, POLEFN, POSTMD, POSTMN, PORTSD, PORTSN, POBOLD, POBOL
IN, PORESN, POFLR, POLL, NYTTYM, DAYTYM, POBOLX, TFACD, TFACH, TOPRES, PRES,
2RESNID, NEWDAY, LEFWT, SUMLEF, SUMSTM, SUMRTS)
3INHOD, NOHOD, NOBR, FAGE, NVEG, NBRV, FRV, FAGV, NFL, ADD, NSTRES)
CALL PDAYZ(STRESS, STRLMT, POLEFD, POSTMD, PORTSD, POBOLD, TRES, PRES,
1PN, RESUFC, LEFWT, XSTRES, TRNSLF, LEAFW, STMW, ROTW)
CALL PONYTZ(POLEFN, POSTMN, PORTSN, POBOLN, PORESN, POFLR, TRES,

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PROGRAM LISTING—Continued

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135 1LEFWT, PRES, TUPRES, HISTD, LOSTD, XTRES, LEFSTF, POLYNA, RESDFC,
136 2PN, TOPRSF, STRESS, RFALL)
137 CALL PLTNAP(PBOLL, WTBOLL, TAVG, NEWDAY, PQBOLN, PQBOLD, PQBOLX, XTRES,
138 1NOBR1, NONOD, BOLLST, SQLOST, COTXX, GRCOTX, ROWSP, PQFLR, POLYNA, FAGE,
139 2INOD, NOBR, POPPLT, NUMGRN, NUMOPN, NVEG, NBRV, FRV, FAGV, WTBOLV, NV, BLOOM,
140 3LEAFW, LEFWT, NFL, CLIMAT, STNW, ROTW, GBLOS, WLOST, NSTRES)
141 CALL NITR(RDEP, POM, EFN, TENN, NMAX, NMIN, ROWSP, PERN, POPPLT,
142 1NPART, NSTRES, RESN, DREON, DEFCIT, USE, LCONC, H2ODEF, H2OCAP, GBLOS,
143 2LEFWT, COTXX, GRCOTX, RFALL, JJK, FRVL, WS, WR)
144 WS=WS+WLOST(1)
145 WR=WR+WLOST(2)
146 PLANT=LEFWT+STNW+ROOTWT+GRCOTX+COTXX+PRES+WLOST(1)+WLOST(2)+WLO3
147 *T(3)
148 PLANTW=PLANT-COTXX
149 DO 180 J=1,10
180 H2OREM=H2OREM+SOILW(J)
151 H2OREX=H2OREM
152 BALECT=COTXX*BALEFC
153 LAI=LEFWT*ALAIFC/POPEAC
154 IF(1.LT.ISTSQR+1)GO TO 750
155 NSUM=0
156 NSUMB=0
157 NSUMNO=0
158 NCOUNT=0
159 NSUMSQ=0
160 NSUMBO=0
161 DO 728 L=1, NONOD
162 DO 728 M=1, NOBR1
163 IF(FR(L,M).EQ.0)GO TO 728
164 IF(FR(L,M).EQ.1)PRT(L,M)=CHARX
165 IF(FR(L,M).EQ.2)PRT(L,M)=CHARS
166 IF(FR(L,M).EQ.3)PRT(L,M)=CHARN
167 IF(FR(L,M).EQ.4)PRT(L,M)=CHARO
168 IF(FR(L,M).EQ.5)PRT(L,M)=CHARX
169 IF(FR(L,M).EQ.6)PRT(L,M)=CHARS
170 IF(FR(L,M).EQ.1.OR.FR(L,M).EQ.5)NSUMSQ=NSUMSQ+1
171 IF(FR(L,M).EQ.1.AND.FAGE(L,M).GE.12)NCOUNT=NCOUNT+1
172 IF(FR(L,M).EQ.5.AND.FAGE(L,M).GE.12)NCOUNT=NCOUNT+1
173 IF(FR(L,M).EQ.2.OR.FR(L,M).EQ.6)NSUMBO=NSUMBO+1
174 IF(FR(L,M).EQ.3)NSUMB=NSUMB+1
175 IF(FR(L,M).EQ.4)NSUMNO=NSUMNO+1
176 PRT(L,M)=CHARI
177 728 CONTINUE
178 DO 828 LV=1, NVEG
179 DO 828 MV=1, NBRV
180 IF(FRV(LV,MV).EQ.0)GO TO 828
181 IF(FRV(LV,MV).EQ.1)PRTV(LV,MV)=CHARX
182 IF(FRV(LV,MV).EQ.2)PRTV(LV,MV)=CHARS
183 IF(FRV(LV,MV).EQ.3)PRTV(LV,MV)=CHARN
184 IF(FRV(LV,MV).EQ.4)PRTV(LV,MV)=CHARO
185 IF(FRV(LV,MV).EQ.5)PRTV(LV,MV)=CHARX
186 IF(FRV(LV,MV).EQ.6)PRTV(LV,MV)=CHARS
187 IF(FRV(LV,MV).EQ.1.OR.FRV(LV,MV).EQ.5)NSUMSQ=NSUMSQ+1
188 IF(FRV(LV,MV).EQ.1.AND.FAGV(LV,MV).GE.12)NCOUNT=NCOUNT+1
189 IF(FRV(LV,MV).EQ.5.AND.FAGV(LV,MV).GE.12)NCOUNT=NCOUNT+1
190 IF(FRV(LV,MV).EQ.2.OR.FRV(LV,MV).EQ.6)NSUMBO=NSUMBO+1
191 IF(FRV(LV,MV).EQ.3)NSUMB=NSUMB+1
192 IF(FRV(LV,MV).EQ.4)NSUMNO=NSUMNO+1
193 PRTV(LV,MV)=CHARI
194 828 CONTINUE
195 IF(LAST.EQ.0)GO TO 5005
196 IF(JJ.NE.JJK)GOTO 7000
197 WRITE(6,211)JJ
211 FORMAT(' ', 'HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY
198 1', I4, '?')
199 READ(5,3065) NUMBER
200 WRITE(6,3065)NUMBER
201 3065 FORMAT(15)
202 IF(NUMBER.LE.0)GO TO 30
203 DO 31 I=1,NUMBER
204 WRITE(6,212)JJ
212 FORMAT(' ', 'WHICH FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY ',
205 1 I4, '?')
206 READ(5,1) L, N, FR(L,M)
207 WRITE(6,1) L, N, FR(L,M)
208 31 CONTINUE
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PROGRAM LISTING—Continued

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211 30 CONTINUE
212 WRITE(6,214)JJ
213 214 FORMAT(' ', 'HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY
214 1, I4, ' ')
215 READ(5,3065) NUMBV
216 WRITE(6,3065)NUMBV
217 IF(NUMBV.LE.0)GO TO 33
218 DO 32 I=1,NUMBV
219 WRITE(6,215)JJ
220 215 FORMAT(' ', 'WHICH FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY
221 1 I4, ' ')
222 READ(5,1)LV,MV,FRV(LV,MV)
223 WRITE(6,1)LV,MV,FRV(LV,MV)
224 1 FORMAT(5I5)
225 32 CONTINUE
226 33 CONTINUE
227 WRITE(6,216)JJ
228 216 FORMAT(' ', 'DO YOU WANT PLANT PRINTED OUT ON DAY ', I4, ' ')
229 READ(5,1)JNEXT
230 WRITE(6,1)JNEXT
231 JJK=JJK+JNEXT
232 WRITE(6,213)JJ
233 213 FORMAT(' ', 'IS THERE ANY MORE DATA AFTER DAY ', I4, ' ')
234 READ(5,3070)LAST
235 WRITE(6,3070)LAST
236 3070 FORMAT(I5)
237 7000 CONTINUE
238 5005 CONTINUE
239 NSUM=NSUMSQ+NSUMBO+NSUMNO+NSUMMB-NONOD-NV
240 8010 CONTINUE
241 IF(NBR1.LT.2)GO TO 746
242 NBR2=NBR1-1
243 DO 738 M=1,NBR2
244 M1=NBR1-M+1
245 IF(JJ.NE.JJK)GO TO 8001
246 WRITE(6,739)(PRT(L,M1),L=1,NONOD,2)
247 739 FORMAT(' ', 2X, 32(A1,3X))
248 8001 CONTINUE
249 IF(JJ.NE.JJK)GO TO 8007
250 WRITE(6,739)(PRI(L,M1),L=1,NONOD,2)
251 8007 CONTINUE
252 739 CONTINUE
253 746 CONTINUE
254 IF(JJ.NE.JJK)GO TO 8008
255 WRITE(6,740)(PRT(L,1),L=1,NONOD)
256 740 FORMAT(' ', '= ', 64(A1, '= '))
257 8008 CONTINUE
258 IF(NBR1.LT.2)GO TO 750
259 IF(JJ.NE.JJK)GO TO 8002
260 DO 741 M=2,NBR1
261 WRITE(6,760)(PRI(L,M),L=2,NONOD,2)
262 741 WRITE(6,760)(PRT(L,M),L=2,NONOD,2)
263 760 FORMAT(' ', 4X, 32(A1,3X))
264 750 CONTINUE
265 IF(JJ.NE.JJK)GO TO 8002
266 WRITE(6,751)JJ,XTRES,STRESS,CLIMAT(JJ,1),PLANT
267 751 FORMAT(' ', 'DAY ', I3, ' CH2O STRESS ', I1, ' H2O STRESS ', F4.1, '
268 1 SOLAR RAD ', F5.0, ' PLANT WT ', F6.2)
269 WRITE(6,752)SQLOST,BOLLST,LAI,1,BLOOM
270 752 FORMAT(' ', 'SQUARES LOST ', I2, ' BOLLS LOST ', I2, ' LAI ', F4.2,
271 1 ' PHYSIOL. DAYS ', I3, ' BLOOMS LOST ', I2)
272 WRITE(6,753)LEFWT,NONOD,NSUMSQ,NSUMBO,NSUM
273 753 FORMAT(' ', 'LEAF WT ', F5.2, ' MAINSTEM NODES ', I2, ' # SQUARES '
274 2, I3, ' # GREEN BOLLS ', I2, ' # SITES ', I3, '/')
275 8002 CONTINUE
276 IF(1.LT.1STSQR+1) GO TO 870
277 NBRV2=NBRV-1
278 IF(NBRV2.LT.1) GO TO 846
279 DO 838 MV=1,NBRV2
280 MV1=NBRV-MV+1
281 IF(JJ.NE.JJK)GO TO 8009
282 WRITE(6,739) (PRTV(LV,MV1),LV=1,NVEG,2)
283 WRITE(6,739) (PRIV(LV,MV1),LV=1,NVEG,2)
284 8009 CONTINUE
285 838 CONTINUE
286 846 CONTINUE
287 IF(JJ.NE.JJK)GO TO 8003

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PROGRAM LISTING—Continued

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288      WRITE(6,740) (PRTV(LV,1),LV=1,NV)
289      8003 CONTINUE
290      IF(NBRV2.LT.1) GO TO 850
291      IF(JJ.NE.JJK)GO TO 8005
292      DO 841 NV=2,NBRV
293      WRITE(6,760) (PRIV(LV,MV),LV=2,NVEG,2)
294      841 WRITE(6,760) (PRTV(LV,MV),LV=2,NVEG,2)
295      8005 CONTINUE
296      850 CONTINUE
297      INODV=INOD-1
298      IF(JJ.NE.JJK)GO TO 870
299      IF(INODV.LT.0)GO TO 870
300      WRITE(6,901) INODV
301      901 FORMAT(' ','VEGETATIVE BRANCH GROWING FROM NODE',I3,2X,'OF THE MAI
302      IN STEM',//)
303      8006 CONTINUE
304      870 CONTINUE
305      JJK=JJK-JNEXT
306      IF(JJ.NE.JJK)GO TO 8011
307      IF(LAST.EQ.0)GO TO 5515
308      WRITE(6,220)JJ
309      220 FORMAT(' ','THIS IS DAY ',I4,5X,'WHAT IS THE NEXT OUTPUT DAY?')
310      READ(5,3065)JJK
311      5515 CONTINUE
312      IF(LAST.EQ.1)GO TO 5505
313      JJK=JJK+JB
314      5505 CONTINUE
315      8011 CONTINUE
316      998 CONTINUE
317      LATUDE=LATUDE/RADFAC
318      WRITE(6,1050)BALECT,EMERGE,JSEASN,LATUDE
319      1050 FORMAT(' ','YIELD/ACRE ',F5.3,' EMERGENCE DATE ',F4.0,' GROWING
320      1 DAYS ',I3,' LATITUDE ',F5.1)
321      WRITE(6,1051)NUMGRN,NUMOPN,H2OCAP
322      1051 FORMAT(' ','# GREEN BOLLS ',I2,' # OF OPEN BOLLS ',I2,' SOIL H2O
323      2 CAPACITY ',F4.2)
324      WRITE(6,1052)H2ORUN,ROWSP,POPPLT
325      1052 FORMAT(13H H2O RUN OFF ,F4.2,14H ROW SPACING ,F6.1,19H # OF PLAN
326      1TS/ACRE ,F7.0)
327      STOP
328      END

```

CPRT TF.B

MCKIN*TF.B

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1      SUBROUTINE SUNTYM( JPLDAY,DECL,DAYLNG,SINLAT,COSLAT)
2      C THIS SUBROUTINE COMPUTES THE LENGTH OF DAY FOR ANY DAY OF THE YEAR
3      C JPLDAY IS THE DAY OF PLANTING, DAYLNG IS THE DURATION OF SUNLIGHT
4      C IN HOURS.
5      C DECL REFERS TO A TABLE OF DECLINATIONS GIVING DECLINATIONS FOR EAC
6      DIMENSION DECL(365),PCOT(200,9)
7      COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSQR
8      INTEGER FR(45,8)
9      RADFAC=.0174533
10     JDAY=JJ+JPLDAY
11     DCLVAL=DECL(JDAY)
12     SINDCL= SIN(DCLVAL)
13     COSDCL=COS(DCLVAL)
14     SUNRIZ=(-SINLAT*SINDCL)/(COSLAT*COSDCL)
15     SUNRIZ= ACOS(SUNRIZ)/RADFAC
16     DAYLNG=(SUNRIZ/15.)*2.
17     RETURN
18     END

```

MCKIN*TF.C

```

1      SUBROUTINE WATERZ( CLIMAT,H2OCAP,H2ORUN,STRESS,XSTRES,SOILW,
2      1ESUBT,H2ODEF)
3      C SUBROUTINE WATERZ ADJUSTS SOIL MOISTURE FOR EVAPORATION AND
4      C RAINFALL AND EVALUATES PLANT STRESS IN TERMS OF WATER REMAINING IN
5      C THE SOIL AND THE PAN EVAPORATION FOR THE DAY - ARBITRARILY.
6      C CLIMAT IS RAINFALL AND PAN EVAPORATION FOR THE DAY INDICATED

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PROGRAM LISTING—Continued

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7      C      H2OCAP IS THE USEFUL WATER IN INCHES PER TENTH OF THE ROOTING
8      C      DEPTH
9      C      H2ORUN IS THE COMPUTED RUNOFF OR SOAKTHROUGH
10     C      XSTRESS REFERS TO A TABLE OF VALUES ASSIGNING A NUMERICAL VALUE TO
11     C      THE STRESS RESULTING FROM THE COMBINATION OF SOIL WATER CONTENT AN
12     C      EVAPORATIVE DEMAND AS MEASURED BY PAN EVAPORATION
13     C      SOILW IS THE USEFUL WATER PER TENTH OF THE ROOTING DEPTH
14     C      DIMENSION CLIMAT(300,7),XSTRES(7,5),SOILW(10),ESUBT(5),PCOT(200,9)
15     C      INTEGER EVAP,FR(45,8)
16     C      COMMON /COM/FR, DAY, I, JJ, PCOT, ISTDOR
17     C      COMMON STMT, ROOTWT
18     C      IF (CLIMAT(JJ,5).LT.2.0)EVAP=7
19     C      IF (CLIMAT(JJ,5).LT..47)EVAP=6
20     C      IF (CLIMAT(JJ,5).LT..39)EVAP=5
21     C      IF (CLIMAT(JJ,5).LT..31)EVAP=4
22     C      IF (CLIMAT(JJ,5).LT..23)EVAP=3
23     C      IF (CLIMAT(JJ,5).LT..15)EVAP=2
24     C      IF (CLIMAT(JJ,5).LT..07)EVAP=1
25     C      H2ODEF=0.
26     C      IF (CLIMAT(JJ,4).LT..02)GO TO 175
27     C      DO 153 J=1,10
28     C      153 H2ODEF=H2ODEF+H2OCAP-SOILW(J)
29     C      H2OEXC=CLIMAT(JJ,4)-H2ODEF
30     C      IF (H2OEXC.GT.0.)GO TO 154
31     C      EXIT=0.
32     C      WATER=CLIMAT(JJ,4)
33     C      DO 151 J=1,10
34     C      IF (EXIT.GT.0.)GO TO 151
35     C      XWATER=WATER
36     C      WATER=WATER-H2OCAP+SOILW(J)
37     C      IF (WATER.GT.0.)GO TO 152
38     C      SOILW(J)=SOILW(J)+XWATER
39     C      EXIT=1.
40     C      GO TO 151
41     C      152 SOILW(J)=H2OCAP
42     C      151 CONTINUE
43     C      GO TO 175
44     C      154 H2ORUN=H2ORUN+H2OEXC
45     C      DO 155 J=1,10
46     C      155 SOILW(J)=H2OCAP
47     C      175 EXIT=0.
48     C      PANVAP=CLIMAT(JJ,5)
49     C      K=10
50     C      DO 178 J=1,10
51     C      QH20=SOILW(J)
52     C      IF (EXIT.GT.0.)GO TO 178
53     C      IF (SOILW(J).GT.0.)GO TO 176
54     C      K=K-1
55     C      IF (K.LE.0)K=1
56     C      GO TO 178
57     C      176 KMOIST=((K*5)+45)/10
58     C      PANVAP=PANVAP*ESUBT(KMOIST)
59     C      SOILW(J)=SOILW(J)-PANVAP
60     C      IF (SOILW(J).GT.0.)GO TO 177
61     C      PANVAP=PANVAP-QH20
62     C      NSW=KMOIST
63     C      GO TO 178
64     C      177 EXIT=1.
65     C      NSW=KMOIST
66     C      PANVAP=0.
67     C      178 CONTINUE
68     C      STRESS=XSTRES(EVAP,NSW)
69     C      RETURN
70     C      END

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MCKIN*TF.D

```

1      SUBROUTINE PHZDAZ( CLIMAT, DAYFAC, NYTFAC, DAYLNG, IOLD,
2      1TDAY, THYT, DAYTYM, NYTTYM, TFACD, TFACH, NEWDAY, TAVG)
3      C      DAYFAC IS FRACTION ABOVE MINTEMP FOR DAILY TEMP. AVG.
4      C      NYTFAC IS FRACTION ABOVE MINTEMP FOR NIGHT TEMP. AVG.
5      C      SUBROUTINE PHZDAZ CALCULATES THE LENGTH OF THE PHYSIOLOGICAL DAY A
6      C      BASED ON THE ESTIMATED AVERAGE TEMPERATURE OF EACH DEG.CENTIGRADE
7      C      IOLD=PHYSIOLOGICAL TIME, DEGREE-DAYS FROM START OF PLANT GROWTH
8      C      DIMENSION CLIMAT(300,7), PCOT(200,9)

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PROGRAM LISTING—Continued

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9      COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSOR
10     REAL NYTFAC, MAXMIN, NYTT, NYTTYM
11     INTEGER FR(45,8)
12     IF (CLIMAT(JJ, 2).GT.30.)CLIMAT(JJ, 2)=30.
13     MAXMIN= CLIMAT(JJ, 2)-CLIMAT(JJ, 3)
14     TDAY=MAXMIN*DAYFAC+CLIMAT(JJ, 3)
15     TNYT=MAXMIN*NYTFAC+CLIMAT(JJ, 3)
16     TFACD=(TDAY-12.)/14.
17     IF (TDAY.LT.12.)TFACD=0.
18     TFACN=(TNYT-12.)/14.
19     IF (TNYT.LT.12.)TFACN=0.
20     DAYT=TFACD*DAYLNG
21     DAYTYM=DAYT/24.
22     NYTT=TFACN*(24.-DAYLNG)
23     NYTTYM=NYTT/24.
24     TAVG=(TDAY+TNYT)/2.
25     DAYINC=DAYTYM+NYTTYM
26     DAY=DAY+DAYINC
27     I=(DAY*10.+5.)/10.
28     IF (I.LT.1)I=1
29     NEWDAY=I-IOLD
30     IOLD=I
31     RETURN
32     END

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MCKIN*TF.E

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1      SUBROUTINE PNET(LAI, CLIMAT, POPFAC, PLANTW, DAYTYM, NYTTYM, RSUB0,
2      IFN, STRESS, TDAY, LYTRES, GSUBR, CO2, EFF, ROWSP, NMIN, LCONC)
3      THIS SUBROUTINE CALCULATES NET PHOTOSYNTHESIS(PN) PER DAY PER PLT.
4      CLIMAT IS RADIATION PER DAY
5      DAYTYM AND NYTTYM ARE LENGTHS OF DAY AND NIGHT IN PHYSIOLOGICAL
6      TIME
7      PTSRED IS THE FACTOR BY WHICH LEAF WILTING REDUCES THE RATE OF
8      PHOTOSYNTHESIS
9      RSUBL=COEFFICIENT FOR LIGHT RESPIRATION
10     RSUB0=COEFFICIENT FOR MAINTENANCE RESPIRATION
11     GSUBR=VEGETATION RESPIRATION COEFFICIENT
12     DIMENSION CLIMAT(300,7), PCOT(200,9)
13     REAL LAI, NYTTYM, LYTCPT, LYTRES
14     INTEGER CO2, FR(45,8)
15     COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSOR
16     COMMON STNWT, ROOTWT
17     REAL LCONC, NMIN(5)
18     FNIT=0.75+(0.25/0.012)*(LCONC-NMIN(1))
19     IF (FNIT.LT..75)FNIT=0.75
20     IF (FNIT.GT.1.0)FNIT=1.0
21     Z=2.263-0.19859*(CLIMAT(JJ, 6)-129.)+0.016169*((CLIMAT(JJ, 6)-129.)*
22     1*2)
23     LYTCPT=1.0756+Z/ROWSP
24     IF (LYTCPT.GE.1.)LYTCPT=1.
25     IF (STRESS.LT.10.)PTSRED=.1
26     IF (STRESS.LT.9.)PTSRED=.25
27     IF (STRESS.LT.8.)PTSRED=.5
28     IF (STRESS.LT.7.)PTSRED=.8
29     IF (STRESS.LT.6.)PTSRED=1.
30     WATTSM=CLIMAT(JJ, 1)*.8942
31     PSTAND=2.3908+1.37379*WATTSM-0.00054136*(WATTSM**2)
32     PPLANT=PSTAND*LYTCPT*POPFAC*PTSRED*0.001
33     PPLANT=PPLANT*1.06*EFF*FNIT
34     CO2=CLIMAT(JJ, 7)
35     IF (CO2.EQ.1)PPLANT=PPLANT*1.405
36     CO2 IS A CO2 FERTILIZATION TRIGGER, WHEN EQUAL
37     1. PPLANT IS INCREASED 20% DUE TO 500 PPM CO2.
38     RSUBL=0.0032125+0.0066875*TDAY
39     LYTRES=RSUBL*PPLANT
40     BMIN=PLANTW*RSUB0*(DAYTYM+NYTTYM)
41     PTS=PPLANT-LYTRES-BMIN
42     IF (PTS.LE..01)PTS=0.01
43     PN=PTS/(1.+GSUBR)
44     RETURN
45     END

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PROGRAM LISTING—Continued

MOCKIN*TF.F

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1  SUBROUTINE QPREQZ(PQLEFD, PQLEFN, PQSTMD, PQSTMN, PORTSD, PORTSN, PQBOLD
2  1, PQBOLN, PQRESH, PQFLR, PBOLL, NYTTYM, DAYTYM, PQBOLX, TFACD, TFACN, TOPRES
3  2, PRES, RESADD, NEWDAY, LEFMT, SUMLEF, SUMSTM, SUMRTS, INOD, NONOD,
4  3NOBR, FAGE, NVEG, NBRV, FRV, FAGV, NFL, ADD, NSTRES)
5  THIS SUBROUTINE CALCULATES THE PHOTOSYNTHATE REQUIRED FOR STANDARD
6  GROWTH BY EACH PART OF THE PLANT ON THE DATE BASED ON THE GROWTH
7  OF THE STANDARD PLANT ON THE SAME DAY
8  PQLEFD, PQLEFN, ETC. ARE THE STANDARD REQUIREMENTS FOR DAY (D) AND
9  NIGHT (N) FOR LEAF (LEF) GROWTH, STEM (STM) GROWTH, ETC.
10 PQBOLD IS BOLL REQUIREMENT, PQRESH IS REQUIREMENT FOR REBUILDING
11 DEPLETED RESERVES, PQFLR IS THE METABOLIC COST OF A FLOWER
12 REAL NYTTYM, LEFADD, LEFMT, PCOT(200, 9), PBOLL(60)
13 INTEGER FRV(30, 5), FAGV(30, 5)
14 INTEGER FR(45, 8), FAGE(45, 8)
15 COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSQR
16 COMMON STMWT, ROOTWT
17 XYN=NSTRES
18 REDN=1.-0.4*XYN
19 IF(REDN.LE.0.)REDN=0.
20 LEFADD=ADD
21 SUMLEF=SUMLEF+PCOT(1,5)*LEFADD
22 SUMSTM=SUMSTM+PCOT(1,3)
23 SUMRTS=SUMRTS+PCOT(1,1)
24 QUAN=30000./20498.
25 PCOT(1,5)=PCOT(1,5)*QUAN
26 IF(1.GT.42)GO TO 15
27 PCOT(1,3)=PCOT(1,3)*QUAN
28 PCOT(1,1)=PCOT(1,1)*QUAN
29 GO TO 16
30 15 CONTINUE
31 PCOT(1,3)=(.2+.06*STMWT)*QUAN
32 PCOT(1,1)=(.02+.006*ROOTWT)*QUAN
33 16 CONTINUE
34 PQLEFN=PCOT(1,5)*NYTTYM*LEFADD
35 PQLEFD=PCOT(1,5)*DAYTYM*LEFADD
36 PQSTMD=PCOT(1,3)*DAYTYM
37 PQSTMN=PCOT(1,3)*NYTTYM
38 PORTSD=PCOT(1,1)* DAYTYM
39 PORTSN=PCOT(1,1)* NYTTYM
40 PQBOLD=0.
41 PQBOLN=0.
42 PQRESH=(TOPRES-PRES)*RESADD
43 IF(1.LE.ISTSQR+ 28)GO TO 11
44 DO 10 L=INOD, NONOD
45 DO 10 M=1, NOBR
46 NAGE=FAGE(L, M)- 28+ 6
47 IF(NAGE.LT.1) GO TO 10
48 IF(FR(L, M).EQ.1)GO TO 8
49 IF(FR(L, M).NE.2)GO TO 10
50 IF(NAGE.GT. 60)GO TO 10
51 8 CONTINUE
52 PQBOLD=PBOLL(NAGE)*DAYTYM+PQBOLD
53 PQBOLN=PBOLL(NAGE)*NYTTYM+PQBOLN
54 10 CONTINUE
55 DO 12 LV=3, NVEG
56 DO 12 MV=1, NBRV
57 NAGE=FAGV(LV, MV)- 28+ 6
58 IF(NAGE.LT.1) GO TO 12
59 IF(FRV(LV, MV).EQ.1)GO TO 9
60 IF(FRV(LV, MV).NE.2)GO TO 12
61 IF(NAGE.GT. 60)GO TO 12
62 9 CONTINUE
63 PQBOLD=PBOLL(NAGE)*DAYTYM+PQBOLD
64 PQBOLN=PBOLN+PBOLL(NAGE)*NYTTYM
65 12 CONTINUE
66 11 CONTINUE
67 PQBOLX=PQBOLD+PQBOLN
68 IF(PQBOLX.LE.0)NFL=1
69 IF(PQBOLX.GT.0)NFL=0
70 IF(PQBOLX.LE.0.)PQBOLX=1.
71 RETURN
72 END

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PROGRAM LISTING—Continued

NCKIN*TF.G

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1  SUBROUTINE PDAY2(STRESS, STRLMT, POLEFD, POSTND, PORTSD, PQBOLD, TRES, P
2  IRES, PN, RESUFC, LEFMT, XTRES, TRNSLF, LEAFW, STMW, ROTW)
3  C PDAY2 COMPUTES THE PHOTOSYNTHATE USED FOR PLANT GROWTH FOR THE DA
4  DIMENSION FR(45,8)
5  DIMENSION PCOT(200,9)
6  COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSR
7  COMMON STMW, ROOTW
8  INTEGER XTRES
9  REAL LEAFW
10 REAL LEFMT
11 LEAFW=LEFMT
12 XTRES=0
13 ROTW=ROOTW
14 STMW=STMW
15 TRESXX=PN+TRNSLF
16 PN=PN-TRESXX
17 IF(STRESS.GT.STRLMT) GO TO 41
18 PREQ=POLEFD+POSTND+PQBOLD+PORTSD
19 IF(PREQ.GT.PN)GO TO 40
20 C NO STRESS ON PLANT
21 TRES=PN-PREQ
22 50 LEFMT=LEFMT+POLEFD
23 STMW=STMW+POSTND
24 ROOTW=ROOTW+PORTSD
25 GO TO 200
26 40 PAVAIL=PN+TRES+PRES+RESUFC
27 XTRES=3
28 IF(PREQ.GT.PAVAIL)GO TO 60
29 IF(PREQ.GT.PN+TRES)GO TO 70
30 C USES TEMPORARY RESERVES AND PN ONLY
31 TRES=PN-PREQ
32 GO TO 50
33 70 PRES=PRES-PREQ+PN+TRES
34 C ALL TEMP. RESERVES ARE USED AS WELL AS SOME PERMANENT RESERVES
35 TRES=0.
36 GO TO 50
37 41 PREQ=PQBOLD+PORTSD
38 IF(PREQ.GT.PN)GO TO 42
39 C WATER STRESS ONLY
40 TRES=PN-PREQ
41 51 ROOTW=ROOTW+PORTSD
42 GO TO 200
43 42 PAVAIL=PN+TRES+PRES+RESUFC
44 XTRES=3
45 IF(PREQ.GT.PAVAIL) GO TO 61
46 IF(PREQ.GT.PN+TRES)GO TO 72
47 C PLANT USES PN AND TEMP. RESERVES ONLY
48 TRES=PN+TRES-PREQ
49 GO TO 51
50 72 PRES=PRES-PREQ+PN+TRES
51 C PLANT DIPS INTO PERMANENT RESERVES
52 TRES=0.
53 GO TO 51
54 61 TRES=0.
55 C CARBOHYDRATE STRESS AND MOISTURE STRESS
56 PRES=PRES-PRES*RESUFC
57 F=PAVAIL/PREQ
58 C F=RATIO OF AVAIL PN TO REQUIRED
59 IF(F.LT..5)XTRES=3
60 ROOTW=ROOTW+PORTSD*F
61 PQBOLD=PQBOLD*F
62 GO TO 200
63 60 TRES=0.
64 C CARBOHYDRATE STRESS ONLY
65 PRES=PRES-PRES*RESUFC
66 F=PAVAIL/PREQ
67 LEFMT=LEFMT+POLEFD*F
68 STMW=STMW+POSTND*F
69 PQBOLD=PQBOLD*F
70 200 CONTINUE
71 PN=0.
72 TRES=TRES+TRESXX
73 RETURN
74 END

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PROGRAM LISTING—Continued

MCKIN*TF.H

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1      SUBROUTINE PONYTZ(PQLEFN, PQSTNN, PORTSN, PQBOLN, PQRESN, PQFLR, TRES,
2      LEFWT, PRES, TOPRES, HISTD, LOSTD, XTRES, LEFSTF, POLYNA, RES
3      UFC, FN, TOPRSF, STRESS, RFALL)
4      C POLYNA (POLLINATE) IF GIVEN A VALUE SIGNALS THAT A BOLL MAY BE SET
5      C PONYTZ CALCULATES THE PHOTOSYNTHATE REQUIRED FOR PLANT PARTS FOR T
6      C WILL OCCUR BASED ON THE CALCULATED CARBOHYDRATE STRESS OR LACK OF
7      C NIGHT AND COMPUTES THE WEIGHT GAINS. IT ALSO COMPUTES WHETHER BO
8      C IF A BLOOM IS PRESENT
9      C DIMENSION FR(45,8)
10     C DIMENSION PCOT(200,9)
11     COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSR
12     COMMON STMWT, ROOTWT
13     INTEGER POLYNA, XTRES
14     REAL LEFWT, LOSTD, LEFSTF
15     TOPRES=STMWT*TOPRSF
16     POLYNA=1.0
17     XTRES=0
18     PRESX=PRES
19     TSLINT=LEFWT*LEFSTF
20     IF (TRES.GT.TSLINT) TRES=TSLINT
21     IF (PRESX.LE.0.) PRESX=.001
22     PREQ=PQLEFN+PQSTNN+PORTSN+PQBOLN+PQRESN+PQFLR
23     IF (PREQ.GT.TRES) GO TO 210
24     TRES=TRES-PREQ
25     230 ROOTWT=ROOTWT+PORTSN
26     LEFWT=LEFWT+PQLEFN
27     STMWT=STMWT+PQSTNN
28     PRES=PRES+PQRESN
29     IF (PRES.GT.TOPRES) GO TO 231
30     232 IF (TRES.LT.HISTD) GO TO 600
31     POLYNA=1.
32     GO TO 600
33     231 TRES=TRES+PRES-TOPRES
34     PRES=TOPRES
35     GO TO 232
36     210 PAVAIL=TRES+PRES+RESUFC
37     IF (PREQ.GT.PAVAIL) GO TO 220
38     PRES=PRES-PREQ+TKES
39     TRES=0.
40     ABC=(PRESX-PRES)/PRESX
41     IF (ABC.LT.LOSTD) GO TO 221
42     GO TO 230
43     221 POLYNA=1.0
44     GO TO 230
45     220 TRES=0.
46     PRES=PRES-PRES*RESUFC
47     PREQ2=PREQ-PORTSN
48     IF (PREQ2.GT.PAVAIL) GO TO 240
49     ROOTWT=ROOTWT+(PAVAIL-PREQ2)
50     GO TO 250
51     240 STON=PQLEFN+PQSTNN+PQBOLN+PQRESN+PQFLR
52     F=PAVAIL/STON
53     IF (F.LE..8) XTRES=1
54     IF (F.LE..6) XTRES=2
55     IF (F.LE..4) XTRES=3
56     IF (F.LE..1) XTRES=4
57     LEFWT=LEFWT+PQLEFN*F
58     STMWT=STMWT+PQSTNN*F
59     PQBOLN=PQBOLN*F
60     PRES=PRES+PQRESN*F
61     600 CONTINUE
62     IF (RFALL.GT.0.5) POLYNA=0.
63     RETURN
64     END

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MCKIN*TF.I

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1      SUBROUTINE H1TR(RDEF, POM, EFN, TENN, NMAX, NMIN, ROUSP, PERH, POPPLT,
2      INPART, NSTRES, RESH, DREGN, DEFCIT, USE, LCONC, H2ODEF, H2OCAP, GBLOS,
3      2LEFWT, COTXX, GRCOTX, R, JJK, FRVL, WS, NR)
4      C INTEGER FR(45,8)
5      C DIMENSION PCOT(200,9)
6      C COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSR
7      C COMMON STMWT, ROOTWT

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PROGRAM LISTING—Continued

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8      INTEGER FRVL
9      REAL NMAX(5), NMIN(5), NPART(5), LCONC, LEFR, LEFMT, LEFRS, LEFR1
10     DATA APPL/0., WLEF/0., WSTM/0., WGRCT/0., WROT/0., SCON/0.,
11     DATA BCON/0., WCOTX/0./
12 C     NITROGEN SUBROUTINE FOR SINCOT II
13     BURR=0.
14     DEFCIT=0.
15     SEEDR=0.
16     COTTON=(COTXX+GRCTX)
17     EXC=0.
18     GRGR=COTTON-(WGRCT+WCOTX)
19     XN=.0515*20000./POPPLT
20     NSTRES=0
21     CM=ROWSP
22     CD=30.48
23     CL=(43560./ROWSP/POPPLT)*(30.48**2)
24     VTOT=CM*CD*CL
25     AM=(1./42.)*30.48*(JJ+7)
26     AL=AM
27     AD=(1./28.)*30.48*(JJ+7)
28     IF(AM.GT.CM) AM=CM
29     IF(AL.GT.CL) AL=CL
30     IF(AD.GT.CD) AD=CD
31     VPLT=AM*AD*AL
32     PERN=(VPLT/VTOT)*74.5*POM/POPPLT
33     PERN=PERN*(1.-(H2ODEF/(H2OCAP*10.))**2)
34     TENN=TENN+(VTOT-VPLT)*74.5*POM/(POPPLT*VTOT)
35 C     CARDS INSERTED IF SILE DRESSED, FORM AS FOLLOWS
36     IF(JJ.EQ.40)APPL=66.7
37     IF(APPL.LT.1.) GO TO 1
38     IF(R.LT.0.05) GO TO 1
39     TENN=TENN+(APPL*EFN*453.6)/POPPLT
40     APPL=0.
41 1     XNUP=XN
42     USE=0.
43     SUPR=1.
44     SEEDR=NMAX(2)*COTTON*0.416-NPART(2)
45     BURR=NMAX(3)*COTTON*0.278-NPART(3)
46 22    LEFR=NMAX(1)*LEFMT-NPART(1)
47     STMN=NMAX(4)*STMWT-NPART(4)
48     ROTR=NMAX(4)*ROOTWT-NPART(5)
49     IF(LEFR.LT.0.) LEFR=0.
50     IF(SEEDR.LT.0.) SEEDR=0.
51     IF(BURR.LT.0.) BURR=0.
52     IF(STMN.LT.0.) STMN=0.
53     IF(ROTR.LT.0.) ROTR=0.
54     BREQN=SEEDR*LEFR+BURR*STMN+ROTR
55     SEEDR1=NMAX(2)*GRGR*0.416
56     LEFR1=NMAX(1)*(LEFMT-WLEF)
57     IF(LEFR1.LT.0)LEFR1=0.
58 C     BURMIN=MIN. NITR. REQ FOR BUR GROWTH
59     BURMIN=HMIN(3)*GRGR*0.278
60     BURR1=(NMAX(3)-HMIN(3))*GRGR*0.278
61     STMN1=NMAX(4)*(STMWT-WSTM)
62     ROTR1=NMAX(4)*(ROOTWT-WROT)
63     BOL1=BURMIN+SEEDR1
64     IF(BOL1.LE.0.) BOL1=0.000001
65     REQ1=LEFR1+SEEDR1+BURR1+STMN1+ROTR1+BURMIN
66     IF(H2ODEF.GT.0.5*(H2OCAP*10.))XNUP=XN*0.9
67     IF(H2ODEF.GT.0.6*(H2OCAP*10.))XNUP=XN*0.8
68     IF(H2ODEF.GT.0.8*(H2OCAP*10.))XNUP=XN*0.6
69     IF(H2ODEF.GT.0.9*(H2OCAP*10.))XNUP=XN*0.4
70     IF(H2ODEF.GT.0.95*(H2OCAP*10.))XNUP=XN*0.2
71     IF((PERN+TENN).LT.0.00001)XNUP=XN*0.000001
72     XNUP1=XNUP
73     IF(REQ1.GT.XNUP)GO TO 2
74     IF(REQ1.LE.0.0) REQ1=0.
75     IF(REQ1.LT.XNUP)GO TO 10
76     XNUP=REQ1
77     GO TO 3
78 2     IF(XNUP.LT.BOL1) GO TO 6
79     SUPR=(XNUP-BOL1)/(REQ1-BOL1)
80     IF(SUPR.LT..000001)SUPR=.000001
81     NSTRES=1
82 3     IF(PERN.GE.XNUP) GO TO 4
83     IF(PERN+TENN.GE.XNUP) GO TO 5
84     IF(PERN+TENN.LT.BOL1) GO TO 6

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PROGRAM LISTING—Continued

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85 SUPR1=(PERN+TEMN-BOL1 )/(REQ1-BOL1 )
86 IF(SUPR1.LT.SUPR) SUPR=SUPR1
87 IF(SUPR.LT..000001) SUPR=.000001
88 NSTRES=1
89 5 TEMN=TEMN-XNUP+PERN
90 IF(TEMN.LT.0.0) TEMN=0.
91 4 NPART(1)=LEFR1*SUPR+NPART(1)
92 IF(NPART(1).LT..0001) NPART(1)=.0001
93 NPART(2)=NPART(2)+SEEDR1
94 IF(NPART(2).LT..0001) NPART(2)=.0001
95 NPART(3)=NPART(3)+BURR1
96 NPART(3)=NPART(3)+BURR1*SUPR
97 IF(NPART(3).LT..0001) NPART(3)=.0001
98 NPART(4)=STMR1*SUPR+NPART(4)
99 IF(NPART(4).LT..0001) NPART(4)=.0001
100 NPART(5)=ROTR1*SUPR+NPART(5)
101 IF(NPART(5).LT..0001) NPART(5)=.0001
102 GO TO 20
103 6 DEFCIT=BOL1 -XNUP
104 IF(RESN.GT.0.) GO TO 7
105 NSTRES=3
106 IF(DEFCIT/BOL1.GT.0.67) NSTRES=4
107 NPART(2)=NPART(2)+XNUP*SEEDR1/BOL1
108 IF(NPART(2).LT..0001) NPART(2)=.0001
109 NPART(3)=NPART(3)+XNUP*BURR1/BOL1
110 IF(NPART(3).LT..0001) NPART(3)=.0001
111 TEMN=TEMN-XNUP+PERN
112 IF(TEMN.LT.0.) TEMN=0.
113 GO TO 20
114 7 NPART(2)=NPART(2)+SEEDR1
115 IF(NPART(2).LT..0001) NPART(2)=.0001
116 NPART(3)=NPART(3)+BURR1
117 IF(NPART(3).LT..0001) NPART(3)=.0001
118 NPART(1)=NPART(1)-DEFCIT*LEFRS/RESN
119 IF(NPART(1).LT..0001) NPART(1)=.0001
120 NPART(4)=NPART(4)-DEFCIT*STMR/RESN
121 IF(NPART(4).LT..0001) NPART(4)=.0001
122 NPART(5)=NPART(5)-DEFCIT*ROTR/RESN
123 IF(NPART(5).LT..0001) NPART(5)=.0001
124 TEMN=TEMN-XNUP+PERN
125 NSTRES=2
126 USE=(DEFCIT-RESN)/BOL1
127 IF(USE.GT..1) NSTRES=3
128 IF(USE.GT.0.90) NSTRES=4
129 IF(TEMN.LE.XNUP) TEMN=0.
130 GO TO 20
131 10 IF(DREQN.GT.REQ1) EXC=XNUP1-REQ1
132 IF(DREQN.LT.XNUP1.AND.EXC.GT.0.) EXC=DREQN-REQ1
133 TEMN=TEMN-EXC-REQ1+PERN
134 IF(TEMN.LT.0.) TEMN=0.
135 IF(DREQN-SEEDR1.LE.0.0) GO TO 20
136 NPART(2)=NPART(2)+SEEDR1
137 IF(NPART(2).LT..0001) NPART(2)=.0001
138 NPART(1)=NPART(1)+EXC*LEFR/(DREQN-SEEDR1)+LEFR1
139 IF(NPART(1).LT..0001) NPART(1)=.0001
140 NPART(3)=NPART(3)+EXC*BURR/(DREQN-SEEDR1)+BURR1
141 IF(NPART(3).LT..0001) NPART(3)=.0001
142 NPART(4)=NPART(4)+EXC*STMR/(DREQN-SEEDR1)+STMR1
143 IF(NPART(4).LT..0001) NPART(4)=.0001
144 NPART(5)=NPART(5)+EXC*ROTR/(DREQN-SEEDR1)+ROTR1
145 IF(NPART(5).LT..0001) NPART(5)=.0001
146 20 STMWT=STMWT+WS
147 ROOTWT=ROOTWT+WR
148 LEFRS=NPART(1)-NMIN(1)*LEFWT
149 STMR=NPART(4)-NMIN(4)*STMWT
150 ROTRS=NPART(5)-NMIN(4)*ROOTWT
151 IF(CDTXX+GCOTX.LT.0.01) GO TO 21
152 SCOH=NPART(2)-GBLOS*NPART(2)/COTTON
153 BCON=NPART(3)/(COTTON*0.278)
154 IF(BCON.LT..0001) BCON=.0001
155 NPART(2)=NPART(2)-GBLOS*NPART(2)/COTTON
156 IF(NPART(2).LT..0001) NPART(2)=.0001
157 NPART(3)=NPART(3)-GBLOS*NPART(3)/COTTON
158 IF(NPART(3).LT..0001) NPART(3)=.0001
159 21 STCON=NPART(4)/STMWT
160 IF(STCON.LT..0001) STCON=.0001
161 RCON=NPART(5)/ROOTWT

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PROGRAM LISTING—Continued

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162      LCONC=NPART(1)/LEFWT
163      IF(LCONC.LT..0001) LCONC=.0001
164      IF(LEFRS.LT.0.) LEFRS=0.
165      IF(STMRS.LT.0.) STMRS=0.
166      IF(ROTRS.LT.0.) ROTRS=0.
167      RESN=LEFRS+STMRS+ROTRS
168      IF(RESN.LT.0.) RESN=0.
169      IF(JJ.NE.JJK)GO TO 80
170      WRITE(6,50)LCONC, SCON, BCON, STCON, RCON, NSTRES
171      FORMAT(' ', ' CONCENTRATIONS ', 5F7.4, ' NSTRES=', I2)
172      WRITE(6,75)NPART
173      FORMAT(' ', ' NPART(1-5) ', 5F8.4)
174      CONTINUE
175      50 77 WLEF=LEFWT
176          WGRcot=GRCOTX
177          STMW=STMWT-WS
178          WcotX=COTXX
179          WROT=ROOTWT-WR
180          STMW=STMWT-WS
181          ROOTWT=ROOTWT-WR
182          RETURN
183          END

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MCKIN*CLMCOT.J

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1      SUBROUTINE PLTMAP(PBOLL, WTBOLL, TAVG, HENDAY, PBOLN, PBOLD, PBOLX,
2      XTRES, NOBR1, NONOD, BOLLST, SQLOST, COTXX, GRCOTX, ROWSP, PQFLR, POLYNA,
3      2PAGE, INOD, NOBR, POPPLT, NUMGRN, NUMOPN, NVEG, NBRV, FRV, FAGV, WTBOLV, NV
4      3, BLOOM, LEAFW, LEFWT, NFL, CLIMAT, STMW, ROTW, GBLOS, WLOST, NSTRES, JJK)
5      DIMENSION CLIMAT(300,7)
6      INTEGER JK(45,8)/360*0./, JKV(30,5)/150*0./
7      DIMENSION WLOST(3)
8      DIMENSION STEMW(200), ROOTW(200)
9      COMMON /COM/FR, DAY, I, JJ, PCOT, ISTSOR
10     COMMON STMWT, ROOTWT
11     REAL LEAFW
12     REAL LEFWT
13     REAL LEFWT(200)/200*0./
14     INTEGER SQLOST, BOLLST, BLOOM
15     INTEGER FRV(30,5), FAGV(30,5)
16     DATA AVTEMP/0./, ISQ/0./, TMAIN/0./
17     REAL THPV(30)/30*0./, DSV(30)/30*0./
18     INTEGER NTLV(30)/30*0./
19     REAL TBRV(30)/30*0./, WTBOLV(30,5)
20     INTEGER XTRES, FR(45,8), NTL(45)/45*0./, PAGE(45,8), POLYNA
21     REAL PCOT(200,9), PBOLL(60), WTBOLL(45,8), DSQ(45)/45*0./,
22     1TAVL(45)/45*0./, T(45)/45*0./
23     IF(NSTRES.EQ.1)NSTRES=0
24     ROOTW(JJ)=ROOTWT-ROTW
25     LAST=0
26     GBLOS=0.
27     STEMW(JJ)=STMWT-STMW
28     IF(JJ.LE.24)GO TO 8000
29     STMWT=STMWT-STEMW(JJ-24)
30     ROOTWT=ROOTWT-ROOTW(JJ-24)
31     WLOST(1)=STEMW(JJ-24)
32     WLOST(2)=ROOTW(JJ-24)
33     8000 CONTINUE
34     PQFLR=0.
35     XTRES=0
36     LEFWT(JJ)=LEFWT-LEAFW
37     XM=0.0529-(2.147*POPPLT)/(10.**7)
38     NOBR=2.0+XM*ROWSP+1.
39     C THE '+1.' IS ADDED TO NOBR TO ACCOUNT FOR THE MAIN STEM NODE
40     C WHERE THE BRANCH IS ATTACHED.
41     IF(ISQ.EQ.1)GO TO 3
42     IF(I.GE.31)GO TO 1
43     C AVTEMP IS ACCUMULATED AVG TEMP FOR FIRST 31 DAYS
44     AVTEMP=((JJ-1)*AVTEMP+TAVG)/JJ
45     RETURN
46     1 IF(AVTEMP.LE.27.)GO TO 2
47     ISQ=1
48     ISTSOR=1 +(AVTEMP-27.)*3.
49     INOD=6.+1.333*(AVTEMP-27.)
50     NONOD=INOD

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PROGRAM LISTING—Continued

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51      GO TO 3
52      2 ISTSOR=I
53      ISQ=1
54      INOD=7
55      NONOD=INOD
56      3 IF(I.GE.ISTSOR)GO TO 4
57      RETURN
58      4 IF(I.GT.ISTSOR)GO TO 5
59      NVEG=30
60      NBRV=4.5-0.00002895*POPPLT+1
61      FRLST=0
62      FRLSTV=0
63      IF(NBRV.LT.1)NBRV=1
64      TV=I+2.5
65      MV=1
66      TBRV(1)=I+6.0
67      DSV(1)=JJ
68      DO 6 L=1,INOD
69      IF(LAST.EQ.1)GO TO 6
70      FR(L,1)=4
71      PAGE(L,1)=1
72      6 CONTINUE
73      TMAIN=I +2.5
74      T(INOD)=I +6.0
75      DSO(INOD)=JJ
76      NONOD=INOD
77      NOBR1=2
78      IF(LAST.EQ.1)GO TO 5
79      FR(INOD,2)=1
80      FRV(1,1)=4
81      5 IF(NEWDAY.EQ.0)GO TO 7
82      COTXX=0.
83      GRCOTX=0.
84      NUMGRN=0
85      NUMOPN=0
86      BLOOM=0.
87      7 BOLINC =(PQBOLD+PQBOLN)/PQBOLX
88      IF(NFL.EQ.1)GO TO 901
89      IF(BOLINC .LE..85)*XTRES=1
90      IF(BOLINC .LE..6)*XTRES=2
91      IF(BOLINC .LE..35)*XTRES=3
92      IF(BOLINC .LE..2)*XTRES=4
93      901 CONTINUE
94      IF(NEWDAY.EQ.0)GO TO 630
95      DO 610 L=1,NONOD
96      DO 610 M=1,NOBR1
97      IF(FR(L,M).EQ.0) GO TO 610
98      PAGE(L,M)=PAGE(L,M)+1
99      IF(FR(L,M).NE.1)GO TO 8
100     IF(PAGE(L,M).NE.28)GO TO 8
101     IF(LAST.EQ.1)GO TO 8
102     PQFLR=PQFLR+PCOT(I,7)
103     IF(POLYNA.EQ.1)GO TO 9
104     FR(L,M)=4
105     BLOOM=BLOOM+1.
106     GO TO 8
107     9 FR(L,M)=2
108     8 CONTINUE
109     IF(FR(L,M).NE.2) GO TO 12
110     IF(PAGE(L,M).NE.76) GO TO 10
111     IF(LAST.EQ.1)GO TO 10
112     FR(L,M)=3
113     10 CONTINUE
114     IF(.J.EQ.JJK.AND.LAST.EQ.1.AND.FR(L,M).EQ.2.AND.PAGE(L,M).LT.28)
115     1 PAGE(L,M)=28
116     NAGE=PAGE(L,M)- 28
117     IF(NAGE.LT.1)GO TO 610
118     IF(NAGE.GT.60 )NAGE=50
119     IF(FR(L,M).NE.2) GO TO 12
120     NUMGRN=NUMGRN+1
121     WTBOLL(L,M)=WTBOLL(L,M)+PBOLL(NAGE)*BOLINC
122     GRCOTX=GRCOTX+WTBOLL(L,M)
123     GO TO 610
124     12 IF(FR(L,M).NE.3) GO TO 610
125     NUMOPN=NUMOPN+1
126     COTXX=COTXX+WTBOLL(L,M)
127     610 CONTINUE

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PROGRAM LISTING—Continued

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128      DO 710 LV=3,NVEG
129      DO 710 MV=1,NBRV
130      IF(FRV(LV,MV).EQ.0) GO TO 710
131      FAGV(LV,MV)=FAGV(LV,MV)+1
132      IF(FRV(LV,MV).NE.1) GO TO 78
133      IF(FAGV(LV,MV).NE.28)GO TO 78
134      IF(LAST.EQ.1)GO TO 78
135      IF(POLYNA.EQ.1) GO TO 79
136      PQFLR=PQFLR+PCOT(I,7)
137      FRV(LV,MV)=4
138      BLOOM=BLOOM+1.
139      GO TO 78
140      79 FRV(LV,MV)=2
141      78 CONTINUE
142      IF(FRV(LV,MV).NE.2) GO TO 82
143      IF(FAGV(LV,MV).NE.76) GO TO 80
144      IF(LAST.EQ.1)GO TO 80
145      FRV(LV,MV)=3
146      80 CONTINUE
147      IF(JJ.EQ.JJK.AND.LAST.EQ.1.AND.FRV(LV,MV).EQ.2.AND.FAGV(LV,MV).LT.
148      128)FAGV(LV,MV)=28
149      NAGE=FAGV(LV,MV)- 28
150      IF(NAGE.LT.1) GO TO 710
151      IF(NAGE.GT.60 )NAGE=60
152      IF(FRV(LV,MV).NE.2) GO TO 82
153      NUMGRN=NUMGRN+1
154      WTBOLV(LV,MV)=WTBOLV(LV,MV)+FBOLL(NAGE)*BOLINC
155      GRCOTX=GRCOTX+WTBOLV(LV,MV)
156      GO TO 710
157      82 IF(FRV(LV,MV).NE.3) GO TO 710
158      NUMOPN=NUMOPN+1
159      COTXX=COTXX+WTBOLV(LV,MV)
160      710 CONTINUE
161      630 CONTINUE
162      IF(JJ.EQ.JJK.AND.LAST.EQ.1)I=TMAIN
163      IF(I.LT.TMAIN)GO TO 14
164      TMAIN=TMAIN+2.5
165      NONOD=NONOD+1
166      T(NONOD)=I +6.0
167      DSQ(NONOD)=JJ
168      IF(LAST.EQ.1)GO TO 14
169      FR(NONOD,1)=4
170      FR(NONOD,2)=1
171      C      BURNING PINHEAD SQUARES
172      IF(CLIMAT(JJ,1).GE.700.)FR(NONOD,2)=4
173      PAGE(NONOD,1)=1
174      14 CONTINUE
175      DO 15 L=INOD,NONOD
176      TAVL(L)=(TAVL(L)+(JJ-DSQ(L))+TAVG)/(JJ-DSQ(L)+1)
177      IF(I.LT.T(L))GO TO 15
178      IF(NTL(L).EQ.1)GO TO 20
179      T(L)=T(L)+0.333*(30.-TAVL(L))
180      NTL(L)=1
181      20 IF(I.LT.T(L))GO TO 15
182      NTL(L)=0
183      TAVL(L)=0.
184      DSQ(L)=JJ
185      ICNOD=0
186      DO 16 M=1,NBRV
187      IF(ICNOD.GT.0)GO TO 16
188      IF(FR(L,M).GT.0) GO TO 16
189      ICNOD=1
190      T(L)=I+6.0
191      IF(LAST.EQ.1)GO TO 17
192      FR(L,M)=1
193      C      BURNING PINHEAD SQUARES
194      IF(CLIMAT(JJ,1).GE.700.)FR(L,M)=4
195      PAGE(L,M)=1
196      17 CONTINUE
197      IF(L.NE.INOD) GO TO 16
198      NOBRI=NOBRI+1
199      16 CONTINUE
200      15 CONTINUE
201      IF(NV.GE.NVEG) GO TO 90
202      IF(JJ.EQ.JJK.AND.LAST.EQ.1)I=TV
203      IF(I.LT.TV) GO TO 90
204      TV=TV+2.5

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PROGRAM LISTING—Continued

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205      NV=NV+1
206      IF(LAST.EQ.1)GO TO 900
207      FRV(NV,1)=4
208  900    CONTINUE
209      IF(NV.LT.3)GO TO 802
210      IF(LAST.EQ.1)GO TO 90
211      FRV(NV,2)=1
212  C      BURNING PINHEAD SQUARES
213      IF(CLIMAT(JJ,1).GE.700.)FRV(NV,2)=4
214      TBRV(NV)=1+6.0
215  800    FAGV(NV,1)=1
216  90    CONTINUE
217      IF(NV.LT.3)GO TO 802
218      DO 95 LV=3,NV
219      TMPV(LV)=(TMPV(LV)*(JJ-DSV(LV))+TAVG)/(JJ-DSV(LV)+1.)
220      IF(1.LT.TBRV(LV)) GO TO 95
221      IF(NTLV(LV).EQ.1) GO TO 97
222      NTLV(LV)=1
223      TBRV(LV)=TBRV(LV)+0.333*(30.-TMPV(LV))
224  97    IF(1.LT.TBRV(LV)) GO TO 95
225      TBRV(LV)=TBRV(LV)+6.0
226      NTLV(LV)=0
227      TMPV(LV)=0.
228      DSV(LV)=JJ
229      IVNOD=0
230      DO 96 MV=1,NBRV
231      IF(IVNOD.GT.0) GO TO 96
232      IF(FRV(LV,MV).GT.0) GO TO 96
233      IVNOD=1
234      IF(LAST.EQ.1)GO TO 95
235      FRV(LV,MV)=1
236  C      BURNING PINHEAD SQUARES
237      IF(CLIMAT(JJ,1).GE.600.)FRV(LV,MV)=4
238      FAGV(LV,MV)=1
239  96    CONTINUE
240  95    CONTINUE
241  802    CONTINUE
242      SQLOST=0.
243      BOLLST=0.
244      XYN=NSTRES
245      TMAIN=TMAIN+1.33*XYN/4.
246      TV=TV+1.33*XYN/3.
247      IF(LAST.EQ.1)GO TO 1000
248      DO 1002 L=INOD,NONOD
249      DO 1002 M=1,NBRV
250      IF(FR(L,M).EQ.5.AND.JK(L,M).EQ.JJ)GO TO 1001
251      IF(FR(L,M).EQ.6.AND.JK(L,M).EQ.JJ)GO TO 1003
252      GO TO 1002
253  1001  FR(L,M)=4
254      SQLOST=SQLOST+1
255      GO TO 1002
256  1003  FR(L,M)=4
257      BOLLST=BOLLST+1
258      GRCOTX=GRCOTX-WTBOLL(L,M)
259      GBLOS=GBLOS+WTBOLL(L,M)
260      WTBOLL(L,M)=0.
261  1002  CONTINUE
262  1000  CONTINUE
263      IF(LAST.EQ.1)GO TO 2000
264      DO 2002 MV=1,NBRV
265      DO 2002 LV=1,NVEG
266      IF(FRV(LV,MV).EQ.5.AND.JKV(LV,MV).EQ.JJ)GO TO 2001
267      IF(FRV(LV,MV).EQ.6.AND.JKV(LV,MV).EQ.JJ)GO TO 2003
268      GO TO 2002
269  2001  FRV(LV,MV)=4
270      SQLOST=SQLOST+1
271      GO TO 2002
272  2003  FRV(LV,MV)=4
273      BOLLST=BOLLST+1
274      GRCOTX=GRCOTX-WTBOLV(LV,MV)
275      GBLOS=GBLOS+WTBOLV(LV,MV)
276      WTBOLV(LV,MV)=0.
277  2002  CONTINUE
278  1000  CONTINUE
279      IF(XTRES.LE.0..AND.NSTRES.EQ.0)GO TO 125
280      DO 114 L=INOD,NONOD
281      T(L)=T(L)+1.33*XYN/4.

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PROGRAM LISTING—Continued

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282      IF(XTRES.EQ.4)T(L)=T(L)+1.50
283      IF(XTRES.EQ.3)T(L)=T(L)+1.20
284      IF(XTRES.EQ.2)T(L)=T(L)+0.60
285      IF(XTRES.EQ.1)T(L)=T(L)+0.20
286      IF(LAST.EQ.1)GO TO 1140
287      DO 114 M=1,NBR
288      IF(FR(L,M).NE.1)GO TO 119
289      IF(XTRES.EQ.0)GO TO 119
290      GO TO (109,110,111,112),XTRES
291 109      IF(FAGE(L,M).GE.12..AND.FAGE(L,M).LE.12.)GO TO 113
292      GO TO 114
293 110      IF(FAGE(L,M).GE.12..AND.FAGE(L,M).LE.12.)GO TO 113
294      GO TO 114
295 111      IF(FAGE(L,M).GE.9.0.AND.FAGE(L,M).LE.12.)GO TO 113
296      GO TO 114
297 112      IF(FAGE(L,M).GE.8.0.AND.FAGE(L,M).LE.13.)GO TO 113
298      GO TO 114
299 113      CONTINUE
300      FR(L,M)=5
301      JK(L,M)=JJ+8
302      GO TO 114
303 119      CONTINUE
304      IF(NSTRES.EQ.0)GO TO 114
305      GO TO (114,116,117,118),NSTRES
306 118      IF(FR(L,M).EQ.2.AND.FAGE(L,M).LE.38)GO TO 120
307      IF(FR(L,M).EQ.1.AND.FAGE(L,M).LE.6)GO TO 114
308 117      IF(FR(L,M).EQ.2.AND.FAGE(L,M).LE.33)GO TO 120
309 116      IF(FR(L,M).EQ.1.AND.FAGE(L,M).LE.3)GO TO 114
310      GO TO 114
311 120      CONTINUE
312      FR(L,M)=6
313      JK(L,M)=JJ+8
314 114      CONTINUE
315 1140      CONTINUE
316      DO 214 LV=1,NVEG
317      TBRV(LV)=TBRV(LV)+1.33*XY1/3.
318      IF(XTRES.EQ.4)TBRV(LV)=TBRV(LV)+1.50
319      IF(XTRES.EQ.3)TBRV(LV)=TBRV(LV)+1.20
320      IF(XTRES.EQ.2)TBRV(LV)=TBRV(LV)+0.60
321      IF(XTRES.EQ.1)TBRV(LV)=TBRV(LV)+0.20
322      IF(LAST.EQ.1)GO TO 2140
323      DO 214 MV=1,NBRV
324      IF(FRV(LV,MV).NE.1)GO TO 219
325      IF(XTRES.EQ.0)GO TO 219
326      GO TO (209,210,211,212),XTRES
327 209      IF(FAGV(LV,MV).GE.12..AND.FAGV(LV,MV).LE.12.)GO TO 213
328      GO TO 214
329 210      IF(FAGV(LV,MV).GE.12..AND.FAGV(LV,MV).LE.12.)GO TO 213
330      GO TO 214
331 211      IF(FAGV(LV,MV).GE.9.0.AND.FAGV(LV,MV).LE.12.)GO TO 213
332      GO TO 214
333 212      IF(FAGV(LV,MV).GE.8.0.AND.FAGV(LV,MV).LE.13.)GO TO 213
334      GO TO 214
335 213      CONTINUE
336      FRV(LV,MV)=5
337      JKV(LV,MV)=JJ+8
338      GO TO 214
339 219      CONTINUE
340      IF(NSTRES.EQ.0)GO TO 214
341      GO TO (214,216,217,218),NSTRES
342 218      IF(FRV(LV,MV).EQ.2.AND.FAGV(LV,MV).LE.38)GO TO 220
343      IF(FRV(LV,MV).EQ.1.AND.FAGV(LV,MV).LE.6)GO TO 214
344      GO TO 214
345 217      IF(FRV(LV,MV).EQ.2.AND.FAGV(LV,MV).LE.33)GO TO 220
346 216      IF(FRV(LV,MV).EQ.1.AND.FAGV(LV,MV).LE.3)GO TO 214
347      GO TO 214
348 220      CONTINUE
349      FRV(LV,MV)=6
350      JKV(LV,MV)=JJ+8
351 214      CONTINUE
352 2140      CONTINUE
353      IF(XTRES.EQ.0)GO TO 126
354      GO TO (130,131,132,133),XTRES
133      TMAIN=TMAIN+1.0
      TV=TV+1.0
      GO TO 126
2      TMAIN=TMAIN+.7

```

PROGRAM LISTING—Continued

```
359      TV=TV+.7
360      GO TO 126
361 131    TMAIN=TMAIN+.4
362      TV=TV+.4
363      GO TO 126
364 130    TMAIN=TMAIN+0.0
365      TV=TV+0.0
366      126 CONTINUE
367      125 CONTINUE
368      IF(JJ.LE.71)GO TO 2141
369      LEFMT=LEFMT-LEAFMT(JJ-70)
370      WLOST(3)=LEAFMT(JJ-70)
371 2141   CONTINUE
372      RETURN
373      END
```

PROGRAM LISTING—Continued

```

@DATA.L COTDA.
DATA006-RLIB69 01/16-16:06:20
000001 DATA FOR SIMCOT II, THE DATA CONSISTS OF SIX SECTIONS, FOUR OF WHICH ARE
000002 REQUIRED BY THE PROGRAM FOR PROPER OPERATION. THE OTHER TWO SECTIONS
000003 MUST BE SUPPLIED BY THE USER TO SIMULATE HIS CROP AT HIS LOCATION. THE
000004 FOLLOWING DATA ARE AN EXAMPLE WHICH THE USER CAN USE TO CONSTRUCT HIS
000005 OWN DATA FILE.
000006 *****
000007 PROGRAM SUPPLIED DATA.
000008 1234567890123456789012345678901234567890123456789012345678901234567890
000009 [ PQRST J[ PQSTM J[ POLEF J[ PQFLR J[ NOT USED]
000010 .020 .20 .20 .00 .10
000011 .020 .20 .20 .00 .05
000012 .020 .20 .20 .00 .20
000013 .020 .20 .20 .00 .30
000014 .020 .20 .20 .00 .40
000015 .020 .20 .20 .00 .48
000016 .020 .20 .20 .00 .56
000017 .020 .20 .20 .00 .64
000018 .020 .20 .20 .00 .72
000019 .020 .20 .20 .00 .80
000020 .030 .30 .30 .00 .92
000021 .030 .30 .30 .00 1.04
000022 .030 .30 .30 .00 1.16
000023 .030 .30 .30 .00 1.28
000024 .030 .30 .30 .00 1.40
000025 .050 .50 .32 .00 1.56
000026 .050 .50 .32 .00 1.72
000027 .050 .50 .32 .00 1.88
000028 .050 .50 .32 .00 2.04
000029 .050 .50 .32 .00 2.20
000030 .080 .80 .48 .00 2.46
000031 .080 .80 .48 .00 2.72
000032 .080 .80 .48 .00 2.98
000033 .080 .80 .48 .00 3.24
000034 .080 .80 .48 .00 3.50
000035 .060 .60 .40 .00 3.70
000036 .060 .60 .40 .00 3.90
000037 .060 .66 .40 .00 4.10
000038 .060 .60 .40 .00 4.30
000039 .060 .60 .40 .00 4.50
000040 .080 .80 .60 .00 4.76
000041 .080 .80 .60 .00 5.02
000042 .080 .80 .60 .00 5.28
000043 .080 .80 .60 .00 5.54
000044 .080 .80 .60 .00 5.80
000045 .080 .80 .60 .00 6.00
000046 .080 .80 .60 .00 6.80
000047 .080 .80 .60 .00 6.80
000048 .080 .80 .60 .00 6.80
000049 .080 .80 .60 .00 6.80
000050 .080 .80 .60 .50 6.80
000051 *****
000052 PROGRAM SUPPLIED DATA. THE FOLLOWING IS THE PBOLL DATA.
000053 .040 .040 .050 .060 .070 .100 .225 .225 .225 .225 .225 .225 .225 .225
000054 .225 .225 .225 .225 .225 .225 .225 .225 .215 .200 .195 .190 .175 .160
000055 .150 .130 .120 .110 .100 .095 .080 .075 .070 .060 .050 .040 .035 .030 .027 .020
000056 .015 .010 .009 .007 .005 .004 .002 .001
000057 *****
000058 USER SUPPLIED DATA. SUPPLY TITLE.
000059 WEATHER FOR COPIAH COUNTY, MISS. , 1972
000060 SUPPLY NUMBER OF DAYS OF WEATHER DATA IN DATA.
000061 187
000062 *****
000063 SUPPLY WEATHER DATA FOR GROWING SEASON.
000064 1234567890123456789012345678901234567890123456789012345678901234567890
000065 [ SOLAR J[ TMAX J[ THIN J[ RFALL J[ EVAP J[ DAY NO J[ C02 ° ]
000066 138.00 80.00 54.00 .06 119.00
000067 468.00 80.00 54.00 .01 120.00
000068 443.00 80.00 54.00 .15 121.00
000069 405.00 86.00 57.00 .20 122.00
000070 208.00 78.00 60.00 1.53 .20 123.00
000071 608.00 79.00 59.00 69 .06 124.00
000072 698.00 77.00 47.00 .25 125.00
000073 589.00 80.00 52.00 .22 126.00
000074 484.00 81.00 50.00 .19 127.00
000075 584.00 76.00 64.00 .18 128.00
000076 584.00 81.00 65.00 .38 .04 129.00
000077 658.00 76.00 60.00 .15 130.00
000078 631.00 74.00 53.00 .22 131.00
000079 446.00 70.00 66.00 .22 132.00

```

PROGRAM LISTING—Continued

000080	212.00	69.00	64.00	.06	.19	133.00
000081	658.00	81.00	60.00	.80	.09	134.00
000082	663.00	80.00	60.00		.19	135.00
000083	698.00	79.00	56.00	.02	.28	136.00
000084	647.00	86.00	54.00		.28	137.00
000085	547.00	92.00	60.00		.27	138.00
000086	656.00	77.00	55.00		.21	139.00
000087	661.00	78.00	58.00		.26	140.00
000088	645.00	87.00	56.00		.33	141.00
000089	657.00	87.00	56.00		.28	142.00
000090	641.00	91.00	61.00		.29	143.00
000091	648.00	90.00	65.00		.25	144.00
000092	635.00	90.00	73.00		.30	145.00
000093	663.00	88.00	61.00		.27	146.00
000094	596.00	90.00	59.00		.33	147.00
000095	596.00	89.00	62.00		.25	148.00
000096	596.00	89.00	60.00		.29	149.00
000097	395.00	90.00	61.00		.24	150.00
000098	692.00	89.00	59.00		.16	151.00
000099	638.00	81.00	57.00		.32	152.00
000100	706.00	86.00	50.00		.25	153.00
000101	707.00	79.00	46.00		.24	154.00
000102	690.00	90.00	54.00		.28	155.00
000103	685.00	89.00	55.00		.26	156.00
000104	630.00	91.00	54.00		.28	157.00
000105	643.00	91.00	60.00		.28	158.00
000106	515.00	97.00	65.00		.26	159.00
000107	532.00	94.00	65.00		.32	160.00
000108	396.00	93.00	62.00		.23	161.00
000109	493.00	92.00	69.00		.20	162.00
000110	515.00	90.00	65.00		.23	163.00
000111	623.00	90.00	68.00	.04	.22	164.00
000112	410.00	92.00	68.00		.27	165.00
000113	301.00	91.00	69.00	.05	.17	166.00
000114	396.00	92.00	66.00	.13	.11	167.00
000115	352.00	89.00	70.00	.24	.11	168.00
000116	656.00	90.00	70.00	.07	.09	169.00
000117	648.00	91.00	71.00		.23	170.00
000118	652.00	89.00	69.00		.28	171.00
000119	657.00	95.00	65.00		.33	172.00
000120	548.00	91.00	68.00	.34	.36	173.00
000121	326.00	92.00	61.00		.20	174.00
000122	301.00	90.00	62.00	.23	.17	175.00
000123	545.00	92.00	71.00		.10	176.00
000124	241.00	89.00	68.00		.22	177.00
000125	584.00	93.00	72.00	.91	.12	178.00
000126	607.00	94.00	73.00		.26	179.00
000127	554.00	93.00	75.00		.36	180.00
000128	215.00	90.00	70.00		.29	181.00
000129	370.00	94.00	68.00	1.53	.08	182.00
000130	602.00	92.00	68.00	.19	.21	183.00
000131	635.00	93.00	73.00		.26	184.00
000132	260.00	93.00	69.00	.11	.28	185.00
000133	278.00	89.00	67.00	.26	.19	186.00
000134	659.00	77.00	67.00	.15	.11	187.00
000135	669.00	81.00	59.00		.25	188.00
000136	692.00	85.00	57.00		.25	189.00
000137	508.00	86.00	55.00		.23	190.00
000138	611.00	89.00	59.00		.18	191.00
000139	551.00	88.00	65.00		.19	192.00
000140	614.00	91.00	63.00		.22	193.00
000141	630.00	92.00	66.00		.27	194.00
000142	568.00	85.00	63.00	.61	.27	195.00
000143	533.00	89.00	62.00	.58	.27	196.00
000144	461.00	90.00	65.00		.24	197.00
000145	598.00	93.00	70.00		.20	198.00
000146	499.00	88.00	68.00	.83	.28	199.00
000147	627.00	90.00	67.00	.45	.20	200.00
000148	663.00	92.00	96.00		.24	201.00
000149	601.00	89.00	68.00	.35	.28	202.00
000150	490.00	91.00	68.00	.02	.27	203.00
000151	671.00	94.00	66.00		.19	204.00
000152	547.00	95.00	70.00		.25	205.00
000153	516.00	94.00	68.00	.02	.22	206.00
000154	551.00	95.00	72.00		.27	207.00
000155	604.00	93.00	71.00		.27	208.00
000156	582.00	93.00	73.00	.50	.29	209.00
000157	561.00	92.00	73.00	.05	.28	210.00
000158	240.00	85.00	70.00		.30	211.00
000159	434.00	84.00	69.00	1.74	.12	212.00
000160	519.00	89.00	69.00	.68	.15	213.00

PROGRAM LISTING—Continued

000161	609.00	90.00	66.00		.05	214.00
000162	492.00	91.00	68.00		.23	215.00
000163	610.00	93.00	68.00		.25	216.00
000164	623.00	93.00	70.00		.26	217.00
000165	626.00	92.00	70.00		.27	218.00
000166	646.00	92.00	69.00		.35	219.00
000167	635.00	95.00	74.00		.34	220.00
000168	589.00	92.00	74.00		.33	221.00
000169	556.00	95.00	73.00		.27	222.00
000170	461.00	93.00	68.00		.30	223.00
000171	441.00	96.00	67.00		.19	224.00
000172	370.00	94.00	66.00		.23	225.00
000173	356.00	91.00	68.00	.09	.18	226.00
000174	532.00	93.00	68.00		.15	227.00
000175	550.00	89.00	68.00	.25	.24	228.00
000176	480.00	92.00	67.00		.27	229.00
000177	521.00	93.00	68.00		.24	230.00
000178	504.00	92.00	68.00		.25	231.00
000179	566.00	96.00	69.00		.24	232.00
000180	498.00	98.00	70.00		.24	233.00
000181	412.00	99.00	73.00		.29	234.00
000182	439.00	97.00	77.00		.28	235.00
000183	509.00	95.00	68.00		.33	236.00
000184	259.00	96.00	68.00		.21	237.00
000185	402.00	94.00	68.00	.41	.22	238.00
000186	319.00	94.00	69.00	.05	.13	239.00
000187	586.00	93.00	68.00		.16	240.00
000188	584.00	89.00	61.00		.27	241.00
000189	551.00	91.00	62.00		.25	242.00
000190	520.00	92.00	61.00		.22	243.00
000191	460.00	95.00	63.00		.23	244.00
000192	385.00	92.00	69.00		.19	245.00
000193	478.00	95.00	67.00	.03	.19	246.00
000194	435.00	96.00	65.00		.18	247.00
000195	270.00	96.00	67.00		.24	248.00
000196	262.00	90.00	70.00		.13	249.00
000197	514.00	93.00	63.00		.12	250.00
000198	472.00	96.00	73.00		.19	251.00
000199	522.00	98.00	72.00		.22	252.00
000200	495.00	95.00	73.00		.24	253.00
000201	539.00	95.00	68.00		.30	254.00
000202	401.00	91.00	69.00		.21	255.00
000203	485.00	96.00	72.00		.15	256.00
000204	514.00	96.00	61.00		.20	257.00
000205	530.00	97.00	65.00		.30	258.00
000206	503.00	99.00	64.00		.26	259.00
000207	286.00	94.00	67.00		.24	260.00
000208	365.00	96.00	66.00	1.43	.12	261.00
000209	518.00	98.00	69.00	.02	.15	262.00
000210	483.00	94.00	70.00		.23	263.00
000211	478.00	95.00	67.00	.44	.21	264.00
000212	399.00	91.00	66.00		.20	265.00
000213	200.00	90.00	68.00	1.31	.16	266.00
000214	355.00	91.00	68.00	.62	.05	267.00
000215	238.00	90.00	66.00		.13	268.00
000216	162.00	88.00	72.00		.13	269.00
000217	361.00	87.00	67.00		.08	270.00
000218	343.00	88.00	70.00	.45	.17	271.00
000219	365.00	89.00	70.00	.29	.18	272.00
000220	387.00	87.00	69.00	1.22	.12	273.00
000221	544.00	78.00	57.00		.34	274.00
000222	528.00	72.00	41.00		.19	275.00
000223	518.00	78.00	43.00		.15	276.00
000224	456.00	78.00	54.00		.17	277.00
000225	409.00	88.00	65.00	.02	.14	278.00
000226	410.00	87.00	65.00		.17	279.00
000227	355.00	85.00	58.00		.17	280.00
000228	391.00	76.00	64.00		.17	281.00
000229	385.00	78.00	52.00		.09	282.00
000230	395.00	81.00	52.00		.12	283.00
000231	400.00	87.00	51.00		.12	284.00
000232	432.00	86.00	55.00		.17	285.00
000233	409.00	86.00	55.00		.14	286.00
000234	361.00	89.00	58.00		.14	287.00
000235	416.00	90.00	59.00		.14	288.00
000236	339.00	81.00	66.00		.17	289.00
000237	402.00	86.00	53.00		.15	290.00
000238	393.00	90.00	67.00		.15	291.00
000239	351.00	89.00	67.00		.16	292.00
000240	104.00	78.00	50.00	.13	.26	293.00
000241	376.00	70.00	37.00	.03	.05	294.00

PROGRAM LISTING—Continued

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000242      271.00      75.00      51.00      .08      295.00
000243      43.00      78.00      61.00      .07      296.00
000244      346.00      79.00      65.00      1.75      297.00
000245      141.00      67.00      52.00      .02      298.00
000246      81.00      60.00      39.00      .11      299.00
000247      34.00      57.00      38.00      .03      300.00
000248      262.00      65.00      52.00      .55      301.00
000249      84.00      69.00      48.00      .02      302.00
000250      71.00      73.00      52.00      .03      303.00
000251      72.00      82.00      54.00      .08      304.00
000252      172.00      86.00      66.00      .00      305.00
000253      *****
000254      PROGRAM SUPPLIED DATA, TABLE OF DECLINATION VALUES FOR SUN.
000255      1234567890123456789012345678901234567890123456789012345678901234567890
000256      -2304      -2342      -2213      -2137      -1908      -1719
000257      -2054      -2005      -1909      -1808      -1719
000258      -1610      -1455      -1337      -1215
000259      -1050      -923      -753      -621
000260      -448      -304      -139      -005
000261      130      304      414      546
000262      717      846      1012      1135
000263      1256      1413      1450      1602
000264      1709      1811      1909      2002
000265      2049      2130      2157      2228
000266      2310      2322      2327      2325
000267      2317      2310      2252      2228
000268      2157      2121      2038      1950
000269      1857      1814      1712      1606
000270      1455      1341      1223      1102
000271      936      835      707      537      406
000272      253      234      101      032      -206
000273      -253      -426      -548      -729
000274      -858      -1025      -1150      -1312
000275      -1411      -1527      -1638      -1745
000276      -1848      -1945      -2036      -2121      -2141
000277      -2216      -2245      -2306      -2320
000278      -2306      -2325      -2317
000279      *****
000280      PROGRAM SUPPLIED DATA, TABLE OF WATER STRESS VALUES.
000281      1234567890123456789012345678901234567890123456789012345678901234567890
000282      .5      .0      .0      .0      .0      2.5      .2      .0      .0      .0      5.0      2.0      .5      .0      .0
000283      6.8      4.0      2.2      1.0      .5      7.7      5.6      4.0      2.7      2.0      8.7      7.2      6.0      5.0      4.5
000284      9.0      8.5      7.2      6.5      6.0
000285      *****
000286      USER SUPPLIED DATA, USER MUST FURNISH THE FOLLOWING DATA TO SIMULATE HIS CROP.
000287      1234567890123456789012345678901234567890123456789012345678901234567890
000288      [LATITUDE][SEASON][SOIL CAP][EMERGE][ROWSP][LEFADD][PH EFF][POPPLT]
000289      34      170      1.69      125      101.6      1.35      1.0      41000.
000290      [PON][EFN][INITIALN][RESIDN]
000291      1.0      0.60      20.0      30.0
000292      THE FOLLOWING DATA IS USED BY THE PROGRAM TO VARY THE AMOUNT OF OUTPUT
000293      REQUESTED, JJK-FIRST DAY PRINTED OUT, LAST-EQUAL TO ZERO FOR RUN WITHOUT
      MANUAL UPDATING, JB-INCREMENT ADDED TO JJK TO OUTPUT DATA.

```

```

000294      [JJK][LAST][JB]
000295      10      0      10

```


EXAMPLE RUNS

The user of SIMCOT II must employ a data file as illustrated in this manual. Two examples are given. In both examples all the data are the same except for the last line of the data file.

Cotton Growth Simulation Run

Data input: SIMCOT II data file, with emphasis on last line as follows:

```
JJK LAST JB      ← Variables
12345678901234567890 ← Column count
10  0  10      ← The data
```

To execute the program, the user must compile in FORTRAN, map, and execute the absolute element. The data are added to the run-stream after the execute command with proper job control language. Given below is the output of SIMCOT II with the above data file as input to the program. Notice that the plant is listed

every 10th day; however, this can be changed by the user to suit his needs by changing only the last data card.

The normal output in this case prints the plant out in graphical form. The following symbols indicate plant parts: X, square; *, green boll; #, open boll; 0, abscised site or main-stem node; I, fruiting-branch internode; and =, main-stem internode.

Various parameters are also printed out. All are self-explanatory except "concentrations" and "NPART (1-5)." The concentrations are the concentrations of nitrogen by percent in the leaves, seed, burrs, stems, and roots. NPART (1-5) is the nitrogen accumulation by weight in leaves (1), seed (2), burr (3), stems (4), and roots (5).

INPUT DATA

```
@DATA, L CLMDATA., CLMDATA.
DATA006-RLIB67-10 12/05-13:26:31
000001 .020 .20 .20 .00 .10
000002 .020 .20 .20 .00 .05
000003 .020 .20 .20 .00 .20
000004 .020 .20 .20 .00 .30
000005 .020 .20 .20 .00 .40
000006 .020 .20 .20 .00 .48
000007 .020 .20 .20 .00 .56
000008 .020 .20 .20 .00 .64
000009 .020 .20 .20 .00 .72
000010 .020 .20 .20 .00 .80
000011 .030 .30 .30 .00 .92
000012 .030 .30 .30 .00 1.04
000013 .030 .30 .30 .00 1.16
000014 .030 .30 .30 .00 1.28
000015 .030 .30 .30 .00 1.40
000016 .050 .50 .32 .00 1.56
000017 .050 .50 .32 .00 1.72
000018 .050 .50 .32 .00 1.88
000019 .050 .50 .32 .00 2.04
000020 .050 .50 .32 .00 2.20
000021 .080 .80 .48 .00 2.46
000022 .080 .80 .48 .00 2.72
000023 .080 .80 .48 .00 2.98
000024 .080 .80 .48 .00 3.24
000025 .080 .80 .48 .00 3.50
000026 .060 .60 .40 .00 3.70
000027 .060 .60 .40 .00 3.90
000028 .060 .66 .40 .00 4.10
000029 .060 .60 .40 .00 4.30
000030 .060 .60 .40 .00 4.50
000031 .080 .80 .60 .00 4.76
000032 .080 .80 .60 .00 5.02
000033 .080 .80 .60 .00 5.28
000034 .080 .80 .60 .00 5.54
000035 .080 .80 .60 .00 5.80
000036 .080 .80 .60 .00 5.80
000037 .080 .80 .60 .00 5.80
000038 .080 .80 .60 .00 5.80
000039 .080 .80 .60 .00 5.80
000040 .080 .80 .60 .00 5.80
000041 .080 .80 .60 .50 5.80
000042 .040 .040 .050 .060 .070 .100 .225 .225 .225 .225 .225 .225 .225 .225 .225
000043 .225 .225 .225 .225 .225 .225 .225 .225 .225 .215 .200 .195 .190 .175 .160
000044 .150 .130 .120 .110 .100 .095 .080 .075 .070 .060 .050 .040 .035 .030 .027 .020
000045 .15 .010 .009 .007 .005 .004 .002 .001
000046 WEATHER FOR COPIAH COUNTY, MISS., 1972
```

INPUT DATA-Continued

000047	187					
000048	138.00	80.00	54.00		.06	119.00
000049	468.00	80.00	54.00		.01	120.00
000050	443.00	80.00	54.00		.15	121.00
000051	405.00	86.00	57.00		.20	122.00
000052	208.00	78.00	60.00	1.53	.20	123.00
000053	608.00	79.00	59.00	.69	.06	124.00
000054	698.00	77.00	47.00		.25	125.00
000055	589.00	80.00	52.00		.22	126.00
000056	484.00	81.00	50.00		.19	127.00
000057	584.00	76.00	64.00	.10	.18	128.00
000058	584.00	81.00	65.00	.58	.04	129.00
000059	658.00	76.00	60.00		.15	130.00
000060	631.00	74.00	53.00		.22	131.00
000061	446.00	70.00	66.00		.22	132.00
000062	212.00	69.00	64.00	.06	.19	133.00
000063	658.00	81.00	60.00	.80	.09	134.00
000064	663.00	80.00	60.00		.19	135.00
000065	698.00	79.00	56.00	.02	.28	136.00
000066	647.00	86.00	54.00		.28	137.00
000067	547.00	82.00	60.00		.27	138.00
000068	656.00	77.00	55.00		.21	139.00
000069	661.00	78.00	58.00		.26	140.00
000070	645.00	87.00	56.00		.33	141.00
000071	657.00	87.00	56.00		.28	142.00
000072	641.00	91.00	61.00		.29	143.00
000073	648.00	90.00	65.00		.25	144.00
000074	635.00	90.00	73.00		.30	145.00
000075	663.00	88.00	61.00		.27	146.00
000076	596.00	90.00	59.00		.33	147.00
000077	596.00	88.00	62.00		.25	148.00
000078	596.00	89.00	60.00		.29	149.00
000079	395.00	90.00	61.00		.24	150.00
000080	692.00	89.00	59.00		.16	151.00
000081	638.00	81.00	57.00		.32	152.00
000082	706.00	86.00	50.00		.25	153.00
000083	707.00	79.00	46.00		.24	154.00
000084	690.00	90.00	54.00		.28	155.00
000085	685.00	89.00	55.00		.26	156.00
000086	630.00	91.00	54.00		.28	157.00
000087	643.00	91.00	60.00		.28	158.00
000088	515.00	97.00	65.00		.26	159.00
000089	532.00	94.00	65.00		.32	160.00
000090	336.00	93.00	62.00		.23	161.00
000091	493.00	92.00	69.00		.20	162.00
000092	515.00	90.00	65.00		.23	163.00
000093	623.00	90.00	68.00	.04	.22	164.00
000094	410.00	92.00	68.00		.27	165.00
000095	301.00	91.00	69.00	.05	.17	166.00
000096	396.00	92.00	66.00	.13	.11	167.00
000097	352.00	89.00	70.00	.24	.11	168.00
000098	656.00	90.00	70.00	.07	.09	169.00
000099	648.00	91.00	71.00		.23	170.00
000100	652.00	89.00	69.00		.28	171.00
000101	657.00	95.00	65.00		.33	172.00
000102	548.00	91.00	68.00	.34	.36	173.00
000103	326.00	92.00	61.00		.20	174.00
000104	301.00	90.00	62.00	.23	.17	175.00
000105	545.00	92.00	71.00		.10	176.00
000106	241.00	89.00	68.00		.22	177.00
000107	584.00	93.00	72.00	.91	.12	178.00
000108	607.00	94.00	73.00		.26	179.00
000109	554.00	93.00	75.00		.36	180.00
000110	215.00	90.00	70.00		.29	181.00
000111	370.00	94.00	68.00	1.53	.08	182.00
000112	602.00	92.00	68.00	.19	.21	183.00
000113	635.00	93.00	73.00		.26	184.00
000114	260.00	93.00	69.00	.11	.28	185.00
000115	278.00	89.00	67.00	.26	.19	186.00
000116	659.00	77.00	67.00	.15	.11	187.00
000117	669.00	81.00	59.00		.25	188.00
000118	692.00	85.00	57.00		.25	189.00
000119	508.00	86.00	58.00		.23	190.00
000120	611.00	89.00	59.00		.18	191.00
000121	551.00	88.00	65.00		.19	192.00
000122	614.00	91.00	63.00		.22	193.00
000123	630.00	92.00	66.00		.27	194.00
000124	568.00	85.00	63.00	.61	.27	195.00
000125	533.00	89.00	67.00	.58	.27	196.00
000126	461.00	90.00	65.00		.24	197.00
000127	598.00	93.00	70.00		.20	198.00

INPUT DATA—Continued

000128	499.00	88.00	68.00	.83	.28	199.00
000129	627.00	90.00	67.00	.45	.20	200.00
000130	663.00	92.00	96.00		.24	201.00
000131	601.00	89.00	68.00	.35	.28	202.00
000132	490.00	91.00	68.00	.02	.27	203.00
000133	671.00	94.00	66.00		.19	204.00
000134	547.00	95.00	70.00		.25	205.00
000135	516.00	94.00	68.00	.02	.22	206.00
000136	551.00	95.00	72.00		.27	207.00
000137	604.00	93.00	71.00		.27	208.00
000138	582.00	93.00	73.00	.50	.29	209.00
000139	561.00	92.00	73.00	.05	.28	210.00
000140	240.00	85.00	70.00		.30	211.00
000141	434.00	84.00	69.00	1.74	.12	212.00
000142	519.00	89.00	69.00	.60	.15	213.00
000143	609.00	90.00	66.00		.05	214.00
000144	492.00	91.00	68.00		.32	215.00
000145	610.00	93.00	68.00		.25	216.00
000146	623.00	93.00	70.00		.26	217.00
000147	626.00	92.00	70.00		.27	218.00
000148	646.00	92.00	69.00		.25	219.00
000149	635.00	95.00	74.00		.34	220.00
000150	589.00	92.00	74.00		.33	221.00
000151	556.00	95.00	73.00		.27	222.00
000152	461.00	93.00	68.00		.30	223.00
000153	441.00	96.00	67.00		.19	224.00
000154	370.00	94.00	66.00		.23	225.00
000155	356.00	91.00	68.00	.09	.18	226.00
000156	532.00	93.00	68.00		.15	227.00
000157	550.00	89.00	68.00	.25	.24	228.00
000158	480.00	92.00	67.00		.27	229.00
000159	521.00	93.00	68.00		.24	230.00
000160	504.00	92.00	68.00		.25	231.00
000161	566.00	96.00	69.00		.24	232.00
000162	498.00	98.00	70.00		.24	233.00
000163	412.00	99.00	73.00		.29	234.00
000164	439.00	97.00	77.00		.28	235.00
000165	509.00	95.00	68.00		.33	236.00
000166	259.00	96.00	68.00		.21	237.00
000167	402.00	94.00	68.00	.41	.22	238.00
000168	319.00	94.00	69.00	.05	.13	239.00
000169	586.00	93.00	68.00		.16	240.00
000170	584.00	89.00	61.00		.27	241.00
000171	551.00	91.00	62.00		.25	242.00
000172	520.00	92.00	61.00		.22	243.00
000173	460.00	95.00	63.00		.23	244.00
000174	385.00	92.00	69.00		.19	245.00
000175	478.00	95.00	67.00	.03	.19	246.00
000176	435.00	96.00	65.00		.18	247.00
000177	270.00	96.00	67.00		.24	248.00
000178	262.00	90.00	70.00		.13	249.00
000179	514.00	93.00	63.00		.12	250.00
000180	472.00	96.00	73.00		.19	251.00
000181	522.00	98.00	72.00		.22	252.00
000182	495.00	95.00	73.00		.24	253.00
000183	539.00	95.00	68.00		.30	254.00
000184	401.00	91.00	69.00		.21	255.00
000185	485.00	96.00	72.00		.15	256.00
000186	514.00	96.00	61.00		.20	257.00
000187	530.00	97.00	65.00		.30	258.00
000188	503.00	99.00	64.00		.26	259.00
000189	286.00	94.00	67.00		.24	260.00
000190	365.00	96.00	66.00	1.43	.12	261.00
000191	518.00	96.00	69.00	.02	.15	262.00
000192	483.00	94.00	70.00		.23	263.00
000193	478.00	95.00	67.00	.44	.21	264.00
000194	399.00	91.00	66.00		.20	265.00
000195	200.00	90.00	68.00	1.31	.16	266.00
000196	355.00	91.00	68.00	.62	.05	267.00
000197	238.00	90.00	66.00		.13	268.00
000198	162.00	88.00	72.00		.13	269.00
000199	361.00	87.00	67.00		.08	270.00
000200	343.00	88.00	70.00	.45	.17	271.00
000201	365.00	89.00	70.00	.29	.18	272.00
000202	387.00	87.00	69.00	1.22	.12	273.00
000203	544.00	78.00	57.00		.34	274.00
000204	528.00	72.00	41.00		.19	275.00
000205	518.00	78.00	43.00		.15	276.00
000206	458.00	78.00	54.00		.17	277.00
000207	409.00	88.00	65.00	.02	.14	278.00
000208	410.00	87.00	65.00		.17	279.00

INPUT DATA—Continued

000209	355.00	85.00	58.00		.17	280.00
000210	391.00	76.00	64.00		.17	281.00
000211	385.00	78.00	52.00		.09	282.00
000212	395.00	81.00	52.00		.12	283.00
000213	400.00	87.00	51.00		.12	284.00
000214	432.00	96.00	55.00		.17	285.00
000215	409.00	86.00	55.00		.14	286.00
000216	361.00	89.00	58.00		.14	287.00
000217	416.00	90.00	59.00		.14	288.00
000218	339.00	81.00	66.00		.17	289.00
000219	402.00	86.00	53.00		.15	290.00
000220	393.00	90.00	67.00		.15	291.00
000221	351.00	89.00	67.00		.16	292.00
000222	104.00	78.00	50.00	.13	.26	293.00
000223	376.00	70.00	37.00	.03	.05	294.00
000224	271.00	75.00	51.00		.08	295.00
000225	43.00	78.00	61.00		.07	296.00
000226	346.00	79.00	65.00	1.75	.11	297.00
000227	141.00	67.00	52.00	.02	.15	298.00
000228	81.00	60.00	39.00		.11	299.00
000229	34.00	57.00	38.00		.03	300.00
000230	262.00	65.00	52.00	.55	.07	301.00
000231	84.00	69.00	48.00		.02	302.00
000232	71.00	73.00	52.00		.03	303.00
000233	72.00	82.00	54.00		.08	304.00
000234	172.00	86.00	66.00		.00	305.00

000235	-2304		-2242		-2213		-2137	
000236	-2054		-2005		-1909		-1808	-1719
000237		-1610		-1455		-1337		-1215
000238		-1050		-923		-753		-621
000239		-448		-3-4		-139		-005
000240		130		304		414		546
000241		717		846		1012		1135
000242		.1256		1413		1450		1602
000243	1709		1911		1909		2002	
000244	2049		2130		2157		2228	2252
000245		2310		2322		2252		2325
000246		2317		2310		2038		2228
000247		2157		2121		2038		1950
000248		1857		1814		1712		1606
000249	1455		1341		1223		1102	
000250	936		835		707		537	406
000251			234		101		-032	-206
000252		-253		-426		-538		-729
000253		-858		-1025		-1150		-1312
000254	-1411		-1527		-1638		-1745	-2141
000255	-1848		-1945		-2036		-2121	-2320
000256		-2216		-2245		-2306		-2317
000257		-2326		-2325		-2317		
000258		.0	.0	.0	.0	.0	.0	.0
000259	6.8	4.0	2.2	1.0	.5	7.7	5.6	4.0
000260	9.0	8.5	7.2	6.5	6.0			
000261		34		170		1.69		
000262		1.0	0.60	20.0		30.0		
000263	NEW	10	0	10		125	101.6	1.35
								1.0
								41000.

OUTPUT DATA

EXQT CLMCOT.S

WEATHER FOR COPIAH COUNTY, MISS. , 1972

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CONCENTRATIONS      .0420  .0000  .0000  .0200  .0200  NSTRES= 0
NPART(1-5)          .0264  .0001  .0001  .0103  .0004

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```

== =
DAY 10 CH2O STRESS 0 H2O STRESS .0 SOLAR RAD 663. PLANT WT 1.17
SQUARES LOST 0 BOLLS LOST 0 LAI .08 PHYSIOL. DAYS 6 BLOOMS LOST 0
LEAF WT .63 MAINSTEM NODES 0 # SQUARES 0 # GREEN BOLLS 0 # SITES 0

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CONCENTRATIONS      .0420      .0000      .0000      .0200      .0200      NSTRES= 0
NPART(1-5)         .0473      .0001      .0001      .0177      .0008

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==
DAY 20 CH2O STRESS 0 H2O STRESS .5 SOLAR RAD 635. PLANT WT 2.05
SQUARES LOST 0 BOLLS LOST 0 LAI .14 PHYSIOL. DAYS 13 BLOOMS LOST 0
LEAF WT 1.13 MAINSTEM NODES 0 # SQUARES 0 # GREEN BOLLS 0 # SITES 0

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CONCENTRATIONS .00420 .0000 .0000 .0180 .0200 NSTRES= 0
NPART(1-5) .0085 .0001 .0001 .0339 .0042
```

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== =
DAY 30 CH2D STRESS 0 H2O STRESS 1.0 SOLAR RAD 690. PLANT WT 4.04
SQUARES LOST 0 BOLLS LOST 0 LAI .26 PHYSIOL. DAYS 20 BLOOMS LOST 0
LEAF WT 2.11 MAINSTEM NODES 0 # SQUARES 0 # GREEN BOLLS 0 # SITES 0

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```
CONCENTRATIONS      .0420  .0000  .0000  .0176  .0200  NSTRES= 0
NPART(1-5)         .1597  .0001  .0001  .0690  .0130
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== =
DAY 40 CH2O STRESS 0 H2O STRESS 1.0 SOLAR RAD 410. PLANT WT 7.95
SQUARES LOST 0 BOLLS LOST 0 LAI .46 PHYSIOL. DAYS 28 BLOOMS LOST 0
LEAF WT 3.80 MAINSTEM NODES 0 # SQUARES 0 # GREEN BOLLS 0 # SITES 0

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```
CONCENTRATIONS      .0420  .0000  .0000  .0171  .0190  NSTRES= 0
NPORT(1-5)         .2938  .0001  .0001  .1199  .0186
```

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      X      X
      I      I
==0=0=0=0=0=0=0=
      X
DAY 50  CH2O STRESS 0  H2O STRESS .0  SOLAR RAD 301.  PLANT WT 14.04
SQUARES LOST 0  BOLLS LOST 0  LAI .85  PHYSIOL. DAYS 37  BLOOMS LOST 0
LEAF WT 6.99  MAINSTEM NODES 9 # SQUARES 4 # GREEN BOLLS 0 # SITES 4

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VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

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CONCENTRATIONS      .0398  .0000  .0000  .0147  .0117  NSTRES= 0
NPART(1-5)         .4864  .0001  .0001  .1737  .0122

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      X   X
      X   X
      X   X
      X   X
==0=0=0=0=0=0=0=0=0=0=0=0=
      X   X   X   X
      X   X   X   X
      X   X   X   X
DAY 60 CH2O STRESS 0 H2O STRESS .5 SOLAR RAD 260. PLANT WT 22.15
SQUARES LOST 0 BOLLS LOST 0 LAI 1.49 PHYSIOL. DAYS 47 BLOOMS LOST 0
LEAF WT 12.23 MAINSTEM NODES 13 # SQUARES 16 # GREEN BOLLS 0 # SITES 16

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$$\begin{array}{ccccccc} & & \text{X} & & \text{X} & & \text{X} \\ & & | & & | & & | \\ = & \text{O} & = & \text{O} & = & \text{O} & = & \text{O} & = & \text{O} & = & \text{O} & = \\ & & & & | & & | & & & & & & \\ & & & & \text{C} & & \text{C} & & & & & & \end{array}$$

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

[illegible][illegible]

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CONCENTRATIONS      .0210  .0781  .0061  .0063  .0079  NSTRES= 2
NPART(1-5)         .6925  .0781  .0080  .2792  .0106
      X      X

```

OUTPUT DATA—Continued

[illegible]

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DAY 90 CH20 STRESS 3 H2O STRESS .0 SOLAR RAD 492. PLANT WT 67.50
SQUARES LOST 0 BOLLS LOST 0 LAI 4.00 PHYSIOL. DAYS 75 BLOOMS LOST 0
LEAF WT 32.93 MAINSTEM NODES 20 # SQUARES 19 # GREEN BOLLS 15 # SITES 52

```

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

CONCENTRATIONS .0186 .1137 .0037 .0051 .0075 NSTRES= 4
NPART(1-5) .6812 .1137 .0110 .2696 .0105

[illegible]

DAY 100 CH2D STRESS 2 H2D STRESS .5 SOLAR RAD 370. PLANT WT 74.70
SQUARES LOST 0 BOLLS LOST 0 LAI 4.44 PHYSIOL. DAYS 84 BLOOMS LOST 0
LEAF WT 36.54 MAINSTEM NODES 20 # SQUARES 0 # GREEN BOLLS 15 # SITES 52

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

OUTPUT DATA—Continued

```
CONCENTRATIONS .0175 .1053 .0017 .0043 .0070 NSTRES= 4
NPART(1-5) .6851 .1053 .0099 .2694 .0105
```

DAY 110 CH20 STRESS 1 H2O STRESS 2.2 SOLAR RAD 439. PLANT WT 83.58
SQUARES LOST 0 BOLLS LOST 0 LAI 4.75 PHYSIOL. DAYS 94 BLOOMS LOST 0
LEAF WT 39.07 MAINSTEM NODES 20 # SQUARES 0 # GREEN BOLLS 7 # SITES 52

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

CONCENTRATIONS .0167 .1195 .0015 .0037 .0067 NSTRES= 4

```
NPART(1-5)      .6896   .1195   .0113'  .2663   .0108
```

DAY 120	CH2D	STRESS 2	H2O STRESS	.5	SOLAR RAD	385.	PLANT WT	91.90
SQUARES	LOST	0	BOLLS LOST	0	LAI	5.01	PHYSIOL.	DAYS 103
LEAF WT	41.20	MAINSTEM	NODES 20	# SQUARES	0	# GREEN	BOLLS 7	# SITES 52

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

OUTPUT DATA—Continued

```
CONCENTRATIONS .0165 .1344 .0016 .0032 .0063 NSTRES= 3
NPART(1-5) .6923 .1344 .0133 .2643 .0108
```

DAY 130 CH2O STRESS 1 H2O STRESS .5 SOLAR RAD 401. PLANT WT 96.72
SQUARES LOST 0 BOLLS LOST 0 LAI 5.12 PHYSIOL. DAYS 112 BLOOMS LOST 0
LEAF WT 42.08 MAINSTEM NODES 20 # SQUARES 0 # GREEN BOLLS 5 # SITES 52

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

```
CONCENTRATIONS      .0177  .1374  .0017  .0028  .0059  NSTRES= 1
NPART(1-5)          .6948  .1374  .0140  .2730  .0105
```

DAY 140 CH2D STRESS 0 H2O STRESS .0 SOLAR RAD 399. PLANT WT 98.82
SQUARES LOST 0 BOLLS LOST 0 LAI 4.77 PHYSIOL. DAYS 121 BLOOMS LOST 0
LEAF WT 39.21 MAINSTEM NODES 20 # SQUARES 0 # GREEN BOLLS 0 # SITES 52

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

OUTPUT DATA—Continued

```
CONCENTRATIONS .0199 .1374 .0019 .0021 .0052 NSTRES= 0
NPART(1-5) .7034 .1374 .0155 .2238 .0095
```

[illegible]

DAY 150 CH20 STRESS 0 H2O STRESS .0 SOLAR RAD 528. PLANT WT 93.29
SQUARES LOST 0 BOLLS LOST 0 LAI 4.29 PHYSIOL. DAYS 130 BLOOMS LOST 0
LEAF WT 35.28 MAINSTEM NODES 21 # SQUARES 1 # GREEN BOLLS 0 # SITES 53

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

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CONCENTRATIONS      .0193      .1374      .0020      .0018      .0048      NSTRES= 1
NPART(1-5)          .7204      .1374      .0161      .2092      .0091

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[illegible]

DAY 160 CH20 STRESS 0 H2O STRESS .0 SOLAR RAD 432. PLANT WT 94.87
SQUARES LOST 0 BOLLS LOST 0 LAI 4.54 PHYSIOL. DAYS 136 BLOOMS LOST 0
LEAF WT 37.31 MAINSTEM NODES 23 # SQUARES 3 # GREEN BOLLS 0 # SITES 55

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

OUTPUT DATA—Continued

```
CONCENTRATIONS      .0196  .1374  .0021  .0014  .0049  NSTRES= 0
HPART(1-5)         .7409  .1374  .0170  .1743  .0095
```

[illegible]

DAY 170 CH20 STRESS 0 H2O STRESS .0 SOLAR RAD 271. PLANT WT 94.04
SQUARES LOST 0 BOLLS LOST 0 LAI 4.60 PHYSIOL. DAYS 142 BLOOMS LOST 0
LEAF WT 37.80 MAINSTEM NODES 25 # SQUARES 14 # GREEN BOLLS 0 # SITES 66

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

YIELD/ACRE	1.679	EMERGENCE DATE	125.	GROWINGDAYS	172	LATITUDE	34.0
# OF GREEN BOLLS	0	# OF OPEN BOLLS	7	SOIL H2O CAPACITY	1.69		
H2O RUN OFF	.48	ROW SPACING	101.6	# OF PLANTS/ACRE	41000.		

QBRKPT PRINT\$

Insect Damage Experiment

The second way in which SIMCOT II can be used is to directly simulate insect damage by removal (changing the fruiting code) of appropriate fruit. Again the same data file is used with the exception of the last card. This program feature was designed to be used on an on-line interactive basis with a demand or time-share terminal but can be used also with card input in the batch mode.

INPUT DATA

SIMCOT II data file, with emphasis on the last card as follows:

```

JJB LAST JB      +- Variables
12345678901234567890 +- Column count
  75    1    0    +- The data

```

In this example, we will simulate bollworm

damage in which two squares and three bolls are damaged by bollworms.

Step 1.—Execute program and add data file.

Step 2.—Program stops on the 75th day and asks how many fruit are abscised on day 75.

Input: 12345 \leftarrow Column count
1 \leftarrow Data

Which fruit?

Input: 123456789012345 ← Column count
 10 2 4 ← Data

The fruit at the tenth main-stem node and first fruiting-branch node is assigned a 4, which is the code for a scar. The reason a 2 is used to indicate the first fruiting-branch node is that the 1 fruiting-branch node is where the fruiting branch is attached to the main stem. The fruit code is as follows: 1 is a square, 2 is a green boll.

3 is a mature boll, and 4 is a scar. On a printout these codes appear as X, *, #, and 0, respectively.

Next the program asks if any fruit on the vegetative branch will be abscised.

Input: 12345 ← Column count

0 ← Data

Do you want the plant printed out in graphic form?

Input: 12345 ← Column count

1 ← Data (for "no")

0 ← Data (for "yes")

Are there any more data after today? (Are you manually going to abscise any more fruit?)

Input: 12345 ← Column count

0 ← Data (program proceeds normally)

1 ← Data (program will ask for more abscission data)

What is the next output day (day on which more damage will be inflicted or is of special interest to user)?

Input: JJB ← Variable

12345 ← Column count

80 ← Data

Step 3.—Abscise square on day 80 on the vegetative branch with the following set of cards:

12345678901234567890

0 ← No abscission on main stem

1 ← Number abscised on vegetative branch

5 2 4 ← Location on vegetative branch and fruit code

0 ← Print plant

1 ← More data

85 ← Next output day

Step 4.—Abscise boll on main stem on day 85 with the following set of cards:

12345678901234567890

1

9 2 4

0

0

1

90

Step 5.—Abscise boll on main stem on day 90 with the following set of cards:

12345678901234567890

1

8 2 4

0

0

1

95

Step 6.—Abscise boll on the main stem on day 95 with the following set of cards:

12345678901234567890

1

7 2 4

0

0

1

165

Step 7.—Print out plants on desired day (in this case on day 105 near the end of the season).

12345678901234567890

0

0

0

0

The program with the data file as above and the data outlined in the above example will grow a cotton plant which will lose two squares and three bolls due to insect damage. The program output with the mentioned data now follows.

OUTPUT DATA

```

GXQT CLM00T.S
WEATHER FOR COPIAH COUNTY, MISS. ,1972
CONCENTRATIONS .0298 .0006 .0216 .0103 .0078 NSTRES= 1
NPART(1-5) .7525 .0006 .0002 .2781 .0106
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 75?
1
WHICH FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 75?
10 2 4
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY 75 ?
0
DO YOU WANT PLANT PRINTED OUT ON DAY 75?
0
IS THERE ANY MORE DATA AFTER DAY 75?

```

DAY 75 CH20 STRESS 1 H2O STRESS .0 SOLAR RAD 627. PLANT WT 46.32
SQUARES LOST 0 BOLLS LOST 0 LAI 3.07 PHYSIOL. DAYS 60 BLOOMS LOST 0
LEAF WT 25.22 MAINSTEM NODES 18 # SQUARES 38 # GREEN BOLLS 1 # SITES 42

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

```

THIS IS DAY 75 WHAT IS THE NEXT OUTPUT DAY?
80
CONCENTRATIONS .0262 .0078 .0072 .0082 .0077 NSTRES= 2
NPART(1-5) .7524 .0078 .0009 .2792 .0106
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 80?
0
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY 80 ?
1
WHICH FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY 80?
5 2 4
DO YOU WANT PLANT PRINTED OUT ON DAY 80?
0
IS THERE ANY MORE DATA AFTER DAY 80?
1

```

[illegible]

DAY 80 CH20 STRESS 2 H2O STRESS .5 SOLAR RAD 547. PLANT WT 54.75
SQUARES LOST 0 BOLLS LOST 0 LAI 3.50 PHYSIOL. DAYS 65 BLOOMS LOST 0
LEAF WT 28.76 MAINSTEM NODES 20 # SQUARES 43 # GREEN BOLLS 4 # SITES 52

OUTPUT DATA—Continued

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

THIS IS DAY 80 WHAT IS THE NEXT OUTPUT DAY?

```

85
CONCENTRATIONS .0234 .0304 .0063 .0069 .0077 NSTRES= 2
NPART(1-5) .7361 .0304 .0032 .2792 .0106
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 85?

```

HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 55?

WHICH FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 85?

HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY 85 ?

DO YOU WANT PLANT PRINTED OUT ON DAY 85?

IS ⁰THERE ANY MORE DATA AFTER DAY 85?

[illegible]

DAY 95	CH2D	STRESS 2	H2O	STRESS 1.5	SOLAR RAD 551.	PLANT WT 62.74
SQUARES LOST	2	BOLLS LOST	0	LAI 3.82	PHYSIOL. DAYS 70	BLOOMS LOST 0
LEAF WT 31.44	MAINSTEM	NODES 20	# SQUARES	33	# GREEN BOLLS	8 # SITES 52

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

THIS IS DAY 85 WHAT IS THE NEXT OUTPUT DAY?

```

90
CONCENTRATIONS .0213 .0659 .0062 .0062 .0078 NSTRES= 2
NPART(1-5) .7076 .0659 .0068 .2777 .0104
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 90?

```

1
WHICH BRANCH ON MAIN BRANCH WILL BE ASSIGNED ON DAY 000

WHICH FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 30?

HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY 90 ?

DO YOU WANT PLANT PRINTED OUT ON DAY 90?

0
IS THERE ANY MORE DATA AFTER DAY 90?

X
I
*
I
*
I
*

X
I
O
I
*
I
O

X
I
O
I
*

O
I
*

X
I
O

X

X

[illegible][illegible][illegible]

80

OUTPUT DATA—Continued

```
THIS IS DAY 95      WHAT IS THE NEXT OUTPUT DAY?
165
CONCENTRATIONS      .0205 .0955 .0015 .0014 .0051 NSTRES= 1
NPAR(1-5)           .7840 .0955 .0090 .1780 .0099
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY 165?
0
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY 165 ?
0
DO YOU WANT PLANT PRINTED OUT ON DAY 165?
0
IS THERE ANY MORE DATA AFTER DAY 165?
0
```

[illegible]

DAY 165 CH2D STRESS 0 H2O STRESS .0 SOLAR RAD 402. PLANT WT 88.47
SQUARES LOST 0 BOLLS LOST 0 LAI 4.66 PHYSIOL. DAYS 139 BLOOMS LOST 0
LEAF WT 38.29 MAINSTEM NODES 25 # SQUARES 14 # GREEN BOLLS 0 # SITES 66

[illegible]

VEGETATIVE BRANCH GROWING FROM NODE 6 OF THE MAIN STEM

YIELD/ACRE	1.272	EMERGENCE DATE	125.	GROWINGDAYS	172	LATITUDE	34.0
# OF GREEN BOLLS	0	# OF OPEN BOLLS	5	SOIL H2O CAPACITY	1.63		
H2O RUN OFF	.48	ROW SPACING	101.6	# OF PLANTS/ACRE	41000.		

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PART 5.—HARVSIM: A SIMULATION OF COTTON HARVESTING AND GINNING

By James W. Jones,¹ Rex F. Colwick,² D. F. Wanjura,³ and Elmer B. Hudspeth⁴

DESCRIPTION

HARVSIM simulates harvesting, transporting, storing, and ginning of cotton from a farm in a gin community. See figure 5-1. The focus is on a particular farm where field sizes, cotton maturity rates for each field, and yield of each field are descriptions of the crop. The harvesting and hauling system is specified by the number, capacity, and speed of harvesters and the number and capacity of trailers available to the farmer. The rest of the cotton input to the gin from other farms is simulated by random lumped harvesting rates derived from past gin records. The ginning rate is specified, and an option exists for altering the gin schedule. Breakdowns of harvesters and the gin are simulated, and idle harvester time due to trailer shortages is considered. A trailer hauler takes one or two trailers to and from the gin.

The operator specifies the date when harvesting is to start by selecting the percentage of the crop open when harvesting is to start. Rainfall is an input to the model, and depending on the amount of rainfall, harvesting is stopped for 0, 1, 2, 3, or 4 days with certain probabilities. Daily trailer arrivals from the entire gin community are calculated and include arrivals from the farm under study. The system status is updated every

0.1 hour. Harvesting is simulated for each harvester, each harvester having been assigned to a field, and a trailer is assigned to each harvester for filling. Harvester breakdown and repair times are simulated. Harvesting continues until all fields are harvested once unless a trailer shortage prevents the harvester from unloading. Farm management determines whether to harvest each field twice and specifies a value (in bales per acre remaining in the field) below which the field will not be harvested a second time.

A hauler transports one or two full trailers to the gin and returns trailers to the farm. When trailers from the farm arrive at the gin, they are placed in a first-come, first-served queue. A daily operating schedule for the gin is selected, based on gin backlog. Breakdowns and repair times for gin equipment are simulated. An economic analysis calculates costs for harvesting, transporting, and ginning.

HARVSIM was validated with 1-year data from the Texas High Plains. The simulated and observed harvesting rates and trailer requirements compared well for the two farms that were monitored.

LIMITATIONS

HARVSIM was intended for comparing current methods of handling seed cotton with alternate methods that include seed-cotton storage prior to ginning. The model depicts the current trailer method and focuses on an individual farm, but with estimates of harvested cotton

from the rest of the gin community. A second model was developed (HARSTOR) to simulate storage of seed cotton on all farms in a gin community and will be reported later.

HARVSIM is limited to studying individual farm harvesting decisions and the effects of these decisions on costs, harvester idle time,

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labor requirements, etc. Farm decisions throughout a gin community can also be studied, but the lumped gin input will have to be altered to reflect that change. For example, one could study the effect of a constant number of trailers owned by the gin and used on a first-come, first-served basis by changing the community harvesting rates to reflect that process.

The economic analysis for the gin is based totally on High Plains gin data developed at Texas

Technological University, Lubbock.³ A more detailed economic analysis of gin costs is needed to make the model general. The harvesting-hauling economic analysis is based on American Society of Agricultural Engineers cost figures.

³ Sandle, W. D., Smith, M. L., and Fowler, Mark. 1970. An industrial engineering study of the operations through which cotton passes between the farm and the mill. Final report on a Cotton Production Institute Project 68-114. 284 pp. Texas Technological University, Lubbock.

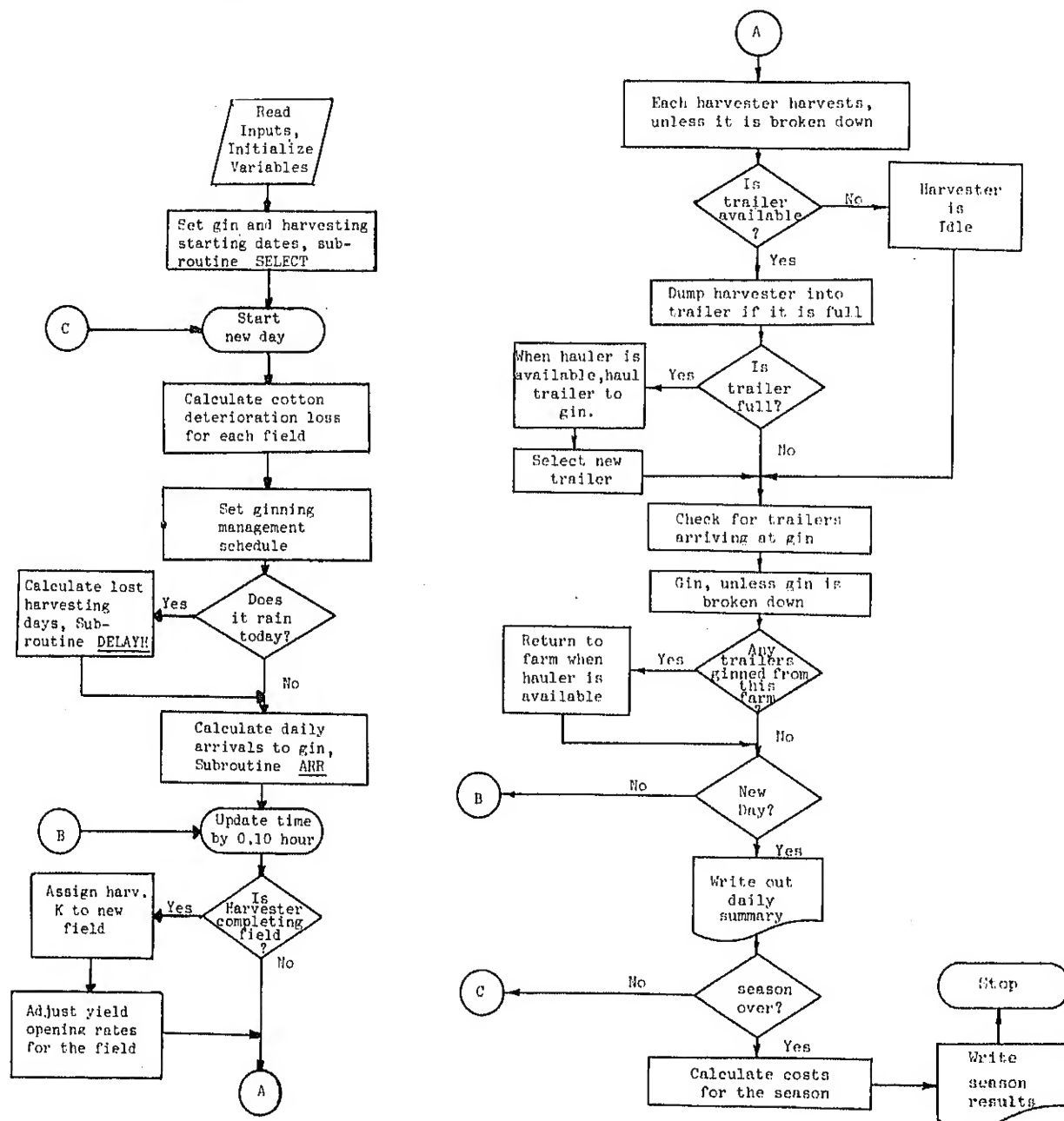


FIGURE 5-1.—Simplified flow chart for HARVSIM.

DEFINITION OF TERMS

ACDELT	Acres harvested in one time increment.	ICNT	Counts empty trailers in gin yard belonging to this farm.
ACS(K)	Number of acres in field K (K=1-50).	IDAL	Days from first open cotton.
ACST	Total acres on farm.	IDAY	Day number.
AIDT	Amount harvested in one time increment.	IDL(J)	Total idle time due to trailer shortages for harvester J.
AR	Bales arriving at gin today from rest of gin community.	IDT	Time counter during day; each increment is 10 minutes.
ARPH	Arrival rate in bales per hour.	IFIELD(K)	Harvester number assigned to field K for harvesting.
BGND	Total bales ginned.	IFK	Field DO loop counter.
BH	Probability of harvester breaking down within a time increment.	IFLAG(K)	Trailer status flag: 0=waiting to be filled, 1=being loaded, 2=trailer full, 3=in transit to gin, 4=in gin queue, 5=empty at gin, and 6=trailer on way home.
BKLG	Bales in gin yard not yet ginned.	IGFLG	Gin operating flag.
BLLS	Total bales harvested from this farm.	IGSTRT	Flag for reading (IGSTRT=0) or calculating gin and harvest starting dates (IGSTRT=1).
CCOT	Cost per pound of lint.	IGT	Number of time increments the gin operates today, at 10 minutes each.
CDEP	Depreciation cost, harvester.	IHARV(J)	Field number assigned to harvester J for harvesting (a pointer).
CFLBR	Cost of farm labor for year.	IHEND	Time of day to stop harvest.
CGIN	Total gin cost per year.	IHLR	Trailer hauler status: 0=on farm, 1=on way to gin, 2=at the gin, 3=on way to farm.
CGLBR	Cost of gin labor for unloading system.	IHSTRT	Time of day for starting harvest (0=6:00 a.m., 10=7:00, etc; daily time increment=0.1 hour).
CHARN	Total harvesting cost per year.	ILAST	Number of days required for season to "tail off" after arrivals start slowing down at end of season.
CHAUL	Total yearly cost for hauling.	IMID	Average number of days for arrivals occurring at the midseason rate, total gin community.
CHL	Cost per mile to operate pickup hauler.	INOTIM	Number of current harvest, 1 or 2.
CINS	Insurance cost, harvester.	IQN(JL)	Time that trailer JL is ginned.
CINT	Interest cost, harvester.	IQUIT	Number of harvesters completed harvesting for the year.
CLBR	Cost per hour for labor.	IRAIN	Flag for reading rain (IRAIN=1) or simulating it (IRAIN=0). (It must be equal to 1 in this program.)
CLOSF	Percentage of cotton loss 30 days after boll opening.	IRDA	Julian days of rainfall input.
CLUB	Lubrication cost per year, harvester.	IRTRN	Time that hauler returns to farm.
COTT(K)	Amount of cotton remaining in field K.	ISH(JFK)	Time when harvester starts harvesting after a breakdown (current time plus repair time).
COTTT	Total seed cotton on farm.	ISTART	Day when harvest is resumed after a rain.
CTAX	Cost of taxes per year (harvester).	ISTRT	Number of days required for gin arrival rate to reach midseason average.
CTLS	Cost per trailer per year.	ITACS	Total acres harvested to date.
CTR	Total trailer cost, all trailers.	JFK	Harvester counter.
DGIN	Daily gin volume.	JFLAG(J)	Harvester status flag: 0=harvester can dump load into harvester and 1=idle harvester.
DLAY	Number of days harvesting delayed due to rain.	KTJ,IZ	Number of trailers hauler pulls to gin this time, 1 or 2.
EFF	Efficiency of harvester.	LBH	Pounds of seed cotton per bale.
ENQ	Time when hauler is to arrive at gin.	LIFE	Years for depreciating harvester.
ENT(JK)	Time trailer JK arrives at gin.		
FLDFLG(K)	Harvest status for field K (0=not yet harvested; 1=harvested once; 2=harvested twice).		
FOX	Percentage of gin volume arriving today, excluding farm in question.		
GAMT	Amount ginned during one time increment.		
GCPB	Ginning cost per bale, from study cited in footnote 5.		
GDT	Repair time for gin.		
GINAR	Midseason daily average gin arrival rate if user wants to specify this.		
GOP	Time gin starts running after breakdown.		
GRTE	Ginning capacity in bales per hour.		
GTO	Gin turnout in percent.		
HAMT(J)	Pounds of seed cotton in harvester J.		
HARC	Purchase price for harvester.		
HARTOL	Tolerance for simulating when the harvester dumps the cotton.		
HPH	Hours of harvester operation.		
IARFLG	Flag for reading in gin arrival rate parameters or simulating (1=read in, 0=simulate).		

MASTRT	First day of open cotton.	SAVCOT	Temporary variable to store amount of cotton remaining in each field.
MATRTE(K,I)	Percent of cotton open on day I (I=1-50 days after MASTRT for field K (K=1-50)).	SGRT	Variation about ginning rate.
NA	Number of days gin arrivals is increasing in trend (=ISTRT if read in).	SMALY	Lowest yield such that if a field has less than SMALY bales per acre in it, then it will not be harvested.
NB	Number of days before gin receipts show decline at end of season (=IMID if read in).	SV	Salvage value of harvester.
NC	End of gin season (=ILAST if read in).	SYA	Standard deviation of YAK.
NDAY	Number of days charged for ginning.	TACRE	Actual time required per acre.
NFLD	Number of fields on the farm, ranked in order of earliness.	TACS(K)	Total acres in field K harvested during current harvest.
NGLBR	Number of gin laborers used for unloading system.	TAMI(K)	Amount of seed cotton in trailer K.
NHAUL	Number of trips (total) made to gin.	TCAP	Trailer capacity.
NHVS	Number of harvesters on the farm.	TCN	Total cotton harvested to date.
NOFTIM	Number of harvests per field, 1 or 2.	TCPB	Total cost per bale harvested on farm.
NRAIN	Number of days of rainfall to read.	TENQ	Total time elapsed when hauler arrives at gin.
NSGN(K)	Harvester number assigned to trailer K.	TIDT	Total time increments.
NTH	Total number of days harvesting, including rain days.	TNBLS	Total arrivals at gin in bales.
NTLS	Number of trailers on the farm.	TQO	Theoretical time per acre.
NYR	Number of years to be simulated.	TRD	Time to drive to or from gin.
PSTART	Percentage of bolls open for starting harvest.	TTRIP	Time required for a harvester round trip in field.
QO	Theoretical acres per hour.	VEL	Average harvesting velocity in miles per hour.
R	Rainfall on day in question.	VOL	Gin community volume in bales.
RFIN(IRDA)	Rainfall amounts on day IRDA.	XMI	Miles to the gin.
RL(K)	Row length in field K (K=1-50).	XO	Amount held by each harvester in pounds.
RO	Probability of gin breakdown during one time increment.	X, RNX	Random numbers.
RT(I)	Time trailer I is scheduled to return to farm.	YA(K)	Yield per acre in field K (K=1-50).
		YAK	(Dummy) yield that has opened.
		YLO	Loss of cotton from a field.
		YLOS	Total lost cotton, accumulated.

INPUT/OUTPUT

Input				
Card 1:	Col. 1-5	NYR (Integer)	Card 25:	Col. 1-10 CTLS (F10.2)
	6-10	NHVS (Integer)		11-20 CHL (F10.2)
	11-15	NTLS (Integer)		21-30 VOL (F10.2)
	16-20	NFLD (Integer)		31-40 HARC (F10.2)
	21-25	NOFTIM (Integer)		41-50 SV (F10.2)
	26-35	XMI (F10.2)		51-55 LIFE (Integer)
	36-45	GTO (F10.2)	Card 26:	Col. 1-10 TCAP (F10.2)
	46-55	CLBR (F10.2)		11-20 CCOT (F10.2)
	56-65	GRTE (F10.2)		21-30 VEL (F10.2)
	66-75	SMALY (F10.2)		31-40 GINAR (F10.2)
				41-45 ISTRT (F5.0)
				51-55 ILAST (F5.0)
				56-60 IARFLG (Integer)
If NFLD is 6:			Card 27:	Col. 1-5 IRAIN (Integer)
Cards 2 through 7; 1 card for each field.				6-10 NRAIN (Integer)
Col. 1-10	ACS (K)	(F10.2)	Card 28:	As many cards as needed, only if
11-20	YA (K)	(F10.2)		rain is read in.
21-30	RL (K)	(F10.2)	Col. 1-5	IRDA (day of rain, Integer)
Card 8:	Col. 1-5	MASTRT (Integer)	6-10	RFIN (IRDA) (F5.2)
	6-15	PSTART (F10.2)	Repeat as needed on same card	
Card 9 through 24: MATRE (K,I) arranged in F4.2 format starting with field 1; 50 values are read in for maturity values for each field K.				

and on following cards if needed.

Card 29:	Col.	1-10	CLOSF	(F10.3)
		11-15	IHSTRT	(Integer)
		16-20	IHEND	(Integer)
		21-30	HARCAP	(F10.3)
Card 30:	Col.	1-5	IGSTRT	(Integer)
		6-10	NSG	(Integer)
		11-15	NGLBR	(Integer)

Output

1. Number of harvesters, trailers, and distance to the gin are printed out.
2. For each field, the number of acres, yield, and row length are printed.
3. The total cotton to harvest, gin starting date, and harvesting starting date.

4. Daily gin summary including the number of arrivals, bales ginned, backlog, and hours of operation.

5. Breakdowns are printed when they occur (gin and harvester).

6. Every time a harvester or trailer changes status, the change is printed out, for example, when a harvester is filled and dumped into a trailer, when a trailer returns to the farm, and when a trailer is ginned are outputs.

7. A daily summary is printed for harvesting and ginning.

8. At the end of the season, the trailer utilization is printed for each trailer. The number of bales harvested, hours of harvester operation, and costs per bale are printed out.

PROGRAM SETUP AND EXECUTION

HARVSIM is programed in FORTRAN for a UNIVAC 1106 or IBM 370 computer. The card reader input unit is 1 and the line printer output unit is 3.

The card deck is arranged in the following sequence for a UNIVAC run:

- A. Control cards
 1. @RUN
 2. @ASG
 3. @FOR
- B. Main program deck
- C. @FOR card (in front of each subroutine)

— Subroutine (s) —
- D. @MAP card

IN card

E. @XQT card

—data—

F. @FIN card

The @RUN card specifies account number, name of run, and the project qualifier. The @ASG card assigns space on disk for storing the program for future use. The @FOR cards cause the main program and subroutines to be compiled with the FORTRAN compiler. The @MAP card creates an absolute element in machine language with all subroutines linked together for the run and for future runs if desirable. The @XQT card causes program execution, and @FIN signals the end of the program.

PROGRAM LISTING

```

C      HARVESTING-HANDLING SIMULATION
      REAL IDL(4),HAMT(4),ENT(30),TAMT(30),RT(30),TE(30),TT(30),REFIN(400)
      1) ISTRT,IMID,ILAST
      DIMENSION X(1)
      INTEGER TIDT
      INTEGER FLDFLG(50),IFIELD(50),IHARV(4)
      INTEGER IFLAG(30),ION(30),ISH(4),NSGM(30),JFLAG(4)
      DIMENSION ACS(50),YA(50),RL(50),COTT(50),TACS(50)
      REAL*4 MAIRTE(50,50)
      DATA IDL/4*0./,HAMT/4*0./,ENT/30*0./,TAMT/30*0./,RT/30*0./,TE/30*0
      1./,TT/30*0./
      DATA TIDT/0./,JFLAG/4*0./,IFLAG/30*0./,ION/30*0./,REFIN/400*0.0/,
      1) ISH /4*0./,NSGM /30*0./,FLDFLG/50*0/
      DATA IHARV/4*0./,IFIELD/50*0./,TACS/50*0.0/,COTT/50*0.0/
C      1971 RAINFALL DATA FOR LUBBOCK, TEXAS
C      NSHIFT=2
C      THE FOLLOWING STATEMENTS INITIALIZE VARIABLES
      IN=1
      DATA NHAUL/0./,IHLR/0./,IATRN/0/
      DATA IUD/0./,BGND/0./,TNRLS/0./,PKLG/0./,GOP/0./,ISTART/0/
      READ IN VARIABLES FOR THIS SIMULATION
      NYR=NUMBER OF YEARS TO BE SIMULATED
      NTL=NUMBER OF TRAILERS HE OWNS
      NHVS=NUMBER OF HARVESTERS FARMER OWNS
      ACS(K) - NO. ACRES IN FIELD K.
      YA(K) - AVERAGE YIELD PER ACRE IN FIELD K
      (ADJUSTED WHEN HARVEST OCCURS)
      RL(K) - ROW LENGTH IN FIELD K.
      COTT(K) - AMOUNT OF COTTON REMAINING EACH FIELD
      XMI=AVERAGE DIST. TO GIN
      GTO=GIN TURNOUT
      CLRR=Labor COST PER HOUR
      GRTE=GIN CAPACITY PER HOUR, RATED
      CLOT=COST PER LB. OF LINT LOST
      NOFTIM - NO. OF TIMES TO HARVEST, 1 OR 2.
      INOTIM - CURRENT HARVEST, 1 = FIRST, 2 = SECOND TIME
      NFLD - NO. OF FIELDS ON THE FARM.
      MASTRT - STARTING DAY NO. FOR READ IN MATURITY CURVES.
      MATRTE(I,K) - MATURITY RATE, PERCENT OF FINAL YIELD OPEN
      ON DAY K, FOR FIELD I.
      SMALY - SMALLEST YIELD THAT WE WILL HARVEST, >=0.0
      IRAIN - FLAG FOR READING IN RAIN OR SIMULATING IT.
      0 = SIMULATED 1 = READ IN
      NHRAIN - NO. OF RAINFALL DAYS TO READ IN.
      IHARV(J) - FIELD NO. ASSIGNED TO HARVESTER J.
      FLDFLG(K) - HARVEST STATUS FOR FIELD
      0 = NOT YET HARVESTED 1 = HARVESTED 1 TIME
      2 = HARVESTED 2 TIMES
      TACS(K) - TOTAL ACRES COMPLETED HARVESTING, FIELD K,
      FOR THIS PARTICULAR HARVEST.
      IQUIT - NO. OF HARVESTERS RETIRED FOR THE SEASON

      READ(1,1) NYR,NHVS,NTL,NFLD,NOFTIM,XMI,GTO,CLRR,GRTE,SMALY
      1) FORMAT(5I5,5F10.2)
      READ(1,1111)(ACS(K),YA(K),RL(K),K=1,NFLD)
      1111) FORMAT(3F10.2)
      READ(1,1140) MASTRT,PSTART
      1140) FORMAT(15,F10.2)
      IN=1
      X(1)=0.62412
      READ(1,1112)((MATRTE(I,K),K=1,50),I=1,NFLD)
      1112) FORMAT(20F4.2)
      READ(1,501) CTL,CHL,VOL,HARC,SV,LIFF
      READ(1,927) TCAP,CCOT,VFL,GINAR,ISTR,IMID,ILAST,IARFLG
      READ(1,760) IRAIN,NRAIN
      760) FORMAT(2I5)
      IF (IRAIN.EQ.1) READ(1,761)(IRDA,REFIN(IRDA),I=1,NRAIN)
      761) FORMAT(8(15,F5.2))
      IQUIT=0
      501) FORMAT(5F10.2,15,F10.2)
      927) FORMAT(4F10.2,3F5.0,15)

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PROGRAM LISTING—Continued

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INOTIM=1
IA=78347
TCAP=(TCAP*479./GTO)*100.
C FOLLOWING STMT. ACCOUNTS FOR EXTRACTOR COTTON
GRTE=GRTE+GRTE*(5.8333*(GTO-21.3)/100.)
C
C
YLO=0.0
YLOS=0.
WRITE(3,610)
610 FORMAT('1',10X,'HARVEST-GIN FOR N.C. STATE EXAMPLE')
WRITE(3,614)
614 FORMAT('0',4X,' NO.HARV. NO.TRAILERS TRAILER CAP.
1 DIST.TO GIN')
WRITE(3,611) 'HVS,ITLS,TCAP,XMI
611 FORMAT('0',21X,I3,8X,I3,9X,F7.1,8X,F5.1,/)
WRITE(3,1109)
1109 FORMAT('0',2X,'FIELD',15X,'ACRES',15X,'YIELD',10X,'ROW LENGTH')
WRITE(3,1113)(IFK,ACS(IFK),YA(IFK),RL(IFK),IFK=1,NFLD)
1113 FORMAT(' ',15,7X,F15.2,5X,F15.2,3X,F15.2)
C START A NEW YEAR
YIR=0
READ(1,759) CLOSE, IHSTRT, IHEND, HARCAP
759 FORMAT(F10.3,2I5,F10.3)
C CLOSE = COTTON LOSS FACTOR
C IHSTRT = BEGIN HARVEST (0 IS 6:00 A.M.)
C IHEND = STOP HARVEST.
1000 YIR=YIR+1
C TON IS TOTAL COTTON HARV THIS YEAR
C TIACS IS TOTAL ACRES HARV THIS YEAR
TON=0.
C SELECT COMPUTES THE GIN STARTING DATE, AND THE HARVEST STARTING DAY
READ(1,751) IGSTRT, NSG, NSH, NGLBR
751 FORMAT(4I5)
ACST=0
CUTTT=0
TIACS=0
DO 1114 IFK=1,NFLD
CUTT(IFK)=(ACS(IFK)*YA(IFK)*100.0/GTO)*479.0
ACST=ACST+ACS(IFK)
1114 CUTTT=CUTTT+CUTT(IFK)
IF(IGSTRT.EQ.1) GO TO 750
CALL SELECT(NSG,NSH,X,Ix,PSTART,MASTRT,MATRTE)
750 WRITE(3,60) NSG,NSH,CUTTT
60 FORMAT(' ', 'GIN STARTING DAY IS',I4,/, 'HARV. STARTING DAY IS',
114,/, 'TOTAL COTTON TO HARVEST IS',F10.1, 'POUNDS',/)
C
C
C
C
C ASSIGNS HARVESTERS TO FIELDS INITIALLY
C IFIELD(K) - HARVESTER NO. ASSIGNED TO FIELD K.
DO 1117 J=1,NHVS
IFIELD(J)=J
1117 THARV(J)=J
C
C IDAY=DAY NO.
DO 999 IDAY=NSG,388
IDAL=IDAY-MASTRT+1
IF(IDAL.GT.50) IDAL=50
C
C IDAL - NO. OF DAYS SINCE SEED COTTON STARTED
C OPENING, MAX. OF 50.
C
C COTTON DETERIORATION FACTOR, CLOSE
IF(IDAY.LT.MASTRT+30) GO TO 1115
IDAQ=IDAY-(MASTRT+30)+1
IF(IDAQ.GT.50) IDAQ=50
DO 1116 IFK=1,NFLD
SAVCOT=COTT(IFK)
CUTT(IFK)=COTT(IFK)*((1.0-(CLOSE*MATRTE(IFK,IDAQ))*((ACS(IFK)-TACS(
1 IFK))/ACS(IFK))))
YLO=SAVCOT-COTT(IFK)
IF(YLO.LT.0.0) YLO=0.0
YA(IFK)=YA(IFK)*((1.0-CLOSE*MATRTE(IFK,IDAQ))
1116 YLOS=YLOS+YLO
WRITE(3,10778) YLOS
10778 FORMAT(' ', 'YLOS=',F10.2)
1115 CONTINUE

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PROGRAM LISTING--Continued

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C      IDT=0
C      DELAYH IS FOR SIMULATING RAIN AND DELAYS IN HARV. DUE TO RAIN
C      ISTART IS STARTING DAY FOR HARVEST AFTER RAINFALL
C      CALL DELAYH(X,NN,R,IDAY,ISTART,IRAIN,RFIN)
C
C      THIS SUBROUTINE CALCULATES ARRIVALS FOR THE DAY AND DETERMINES
C      WHETHER GIN IS RUNNING
C      AR=BALES ARRIVED AT GIN TODAY
C      IGFLG=0 MEANS GIN IS OPERATING; IGFLG=1 MEANS RAINED OUT
C      IF ISTART.GT. IDAY, IAR.GT. 0 AND NO. GIN ARRIVALS FOR DAY
C      NDAY=IDAY-NSG-(IDAY-NSG)/7
C      IAR=ISTART-IDAY
C      CALL ARR(R,X,NN,AR,NDAY,IGFLG,VOL,IAR,GINAR,ISTRT,IMID,TLAST,IARFL
16)
C      IF (IDAY/7*7-IDAY.EQ.0) AR=0
C      IF THERE IS A DELAY IN HARV. DUE TO RAIN, GO TO GINNING
C
C      *****
C      FOLLOWING IS GIN MANAGEMENT SCHEDULE BASED ON BACKLOG.
C
C      IGT=110
C      IF (BKLG.GT.100.AND.NSHIFT.EQ.2) IGT=230
C      IF (BKLG.GT.100.) GRTE=16.8
C      IF (IDAY.GE.NSG+56) IGT=110
C      IF (IDAY.GE.NSG+56) GRTE=16.8
C
C      *****
C      NGIN=0.
C      IGT IS TIME COUNTER DURING DAY
C      20 IGT=IGT+1
C      TIDT=TOTAL NO. OF TIME INCREMENTS
C      TIDT=TIDT+1
C      IF (IDAY.LT.NSH.OR.IDAY.LE.ISTART) GO TO 6
C      IF (IDAY/7*7-IDAY.EQ.0) GO TO 6
C      HARVEST BETWEEN IHSTRT AND IHEND, 0=6:00 A.M.
C      IF (IDT.LE.IHSTRT.OR.IDT.GT.IHEND) GO TO 6
C
C      IF (IQUIT.EQ.NHVS) GO TO 1123
1124 CONTINUE
C
C      CHECK FOR HARVESTERS COMPLETING A FIELD
C
C      DO 1119 JFK=1,NHVS
C      IU=IHARV(JFK)
C      IF (IHARV(JFK).EQ.0) GO TO 1126
C      IF (TACS(IU).LT.ACS(IU)) GO TO 1119
C      IF IELD(IU)=0
C      FLDPLG(IU)=1
C      IF (INOTIM.EQ.2) FLDPLG(IU)=2
C      TACS(IU)=0.0
C      WRITE(3,1130) IHARV(JFK),IDAY,FLDPLG(IU),COTT(IU)
C      YA(IU)=COTT(IU)/(ACS(IU))*GT0/47900.0
7111 WRITE(3,7111) YA(IU)
C      FORMAT(' ',YA,F10.5)
C      IHARV(JFK)=0
1126 CONTINUE
C
C      SELECT NEW FIELD FOR HARVESTER JFK
C
C      DO 1120 IFK=1,NFLD
C      IF (IFIELD(IFK).GT.0) GO TO 1120
C      IF (YA(IFK).LT.SMALY) GO TO 1120
C      IF (MATRTE(IFK,IDAL).LT.n.99.AND.INOTIM.EQ.2) GO TO 1120
C      IF (FLDPLG(IFK).EQ.INOTIM-1) GO TO 1121
1120 CONTINUE
C      IF (INOTIM.EQ.2) IHARV(JFK)=0
C      IF (INOTIM.EQ.2) GO TO 1119
C      IF (NOFTIM.EQ.1) IHARV(JFK)=0
C      IF (NOFTIM.EQ.1) GO TO 1119
C      TACS=0.0
C      INOTIM=2
C      GO TO 1124
1121 IHARV(JFK)=IFK
C      IF IELD(IFK)=JFK
C
C      SELECTED NEW FIELD (IFK) FOR HARVESTER (JFK)

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PROGRAM LISTING—Continued

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IF (IDAL.GE.50) GO TO 1161
IF (MATRTE(IFK,IDAL).GE.0.9999) GO TO 1161
DO 1160 IDA1=IDAL,50
MATRTE(IFK,IDA1)=(MATRTE(IFK,IDA1)-MATRTE(IFK,IDAL))/(1.0-MATRTE(I
IFK,IDAL))
WRITE(3,7112) MATRTE(IFK,IDA1),IDA1
7112 FORMAT(' ','MAT ',F10.5,' IDA1 ',I10)
1160 CONTINUE
1161 CONTINUE
C
C      OPENING RATE IS ADJUSTED TO REMAINING COTTON
C      IN THE FIELD, AFTER FIELD IS HARVESTED 1 TIME.
C
1119 CONTINUE
IQUIT=0
DO 1122 JFK=1,NHVS
1122 IF (IHARV(JFK).EQ.0) IQUIT=IQUIT+1
IF (IQUIT.EQ.NFLD) GO TO 1123
GO TO 4
1123 CONTINUE
1130 FORMAT('0',10X,'COMPLETED HARVESTING FIELD NO.',I5,5X,'ON DAY',I5,
15X,'THIS FIELD HAS BEEN HARVESTED',I2,1X,'TIME',/,',',',',REMAINING C
201TON IS ',F10.0)
C
C
C      CHECK IF ALL TRAILERS ARE GINNED IF ALL COTTON IS HARVESTED
C      DO 5 IE=1,NTLS
IF (TAMT(IE).GT.50.0) GO TO 8018
5 CONTINUE
GO TO 7
4 CONTINUE
C
C
NGH=IDAY
DO 632 IC=1,NTLS
IF (IFLAG(IC).EQ.0.OR.IFLAG(IC).EQ.5.OR.IFLAG(IC).EQ.6) IF (IC)=
1 TL(IC)+0.1
632 T1(IC)=T1(IC)+0.1
HARVESTING CALCULATIONS
FOR EACH HARVESTER, HARVEST DURING AT
DO 8 J=1,NHVS
IF (IHARV(J).EQ.0) GO TO 8
IF (T1(J).LT.TSH(J)) GO TO 8
BREAK DOWN OCCURS EVERY 8 HOURS ON AVERAGE AND REQUIRES 1.2 HOURS
FOR REPAIR ON AVERAGE
RH=1.-EXP(-0.1/8.0)
X(1)=X(1)*8192.*16384.
CALL RANDU(X,NN)
RNX=X(1)
IF (RNX.GT.BH) GO TO 1061
SUH=0.
DO 1062 IR=1,4
X(1)=X(1)*8192.*16384.
CALL RANDU(X,NN)
1062 SUH=SUH+X(1)
RNX=X(1)
DIH=12.*ALOG(1.-RNX)
WRITE(3,1063) J,DT,IDAY,DTH
1063 FORMAT(' ','HARVESTER NO.',I4,'BREAKS DOWN, TIME',I4,'OF DAY',I4,
16X,'REPAIR TIME IS',F6.1,'TIME INCRMENTS')
TSH(J)=T1(J)+ABS(DTH)
1061 CONTINUE
LH=POUNDS OF SEED COTTON PER BALE
LH=(470./GTO)*100
IU=IHARV(J)
YAK=YA(IU)*MATRTE(IU, IDAL)
SYA=YAK/6.0
CALL GAUSS(X,NN,SYA,YAK,VYA)
IF (VYA.GT.1.25) VEL=5.-1.33*(VYA-1.25)
VU=VEL*6.67/8.25
VU=ACRES PER HOUR, THEORETICAL
TWO=THEORETICAL TIME PER ACRE
IF ALL COTTON HAS BEEN HARV, CHECK ON TRAILER STATUS
XU=AMT HELD BY EA. HARV, LBS.
TWO=1./00
A=8910.89/(2.*VEL)
B=163.4/(2.*RL(IU))
XU=LH*HARCAP )/1200.)

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PROGRAM LISTING—Continued

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C=90.*LRH*VYA/XO
IF (IUT.EQ.00) WRITE(3,1010) A,B,C,EFF
1010 FORMAT(' ',3F8.1,6X,F8.3,6X,'A,B,C,EFF')
DT=600.0*(YA(IU) )*MATRTE(IU ,IDAL)/TCAP)
EFF=A/((6./5.)*(A+B+C+DT))
TACRE=T00/EFF
C ACDELT IS ACRES HARV IN DELTA T
ACDELT=(1./TACRE)*0.1
RTRIP=(RL(IU )/6534.)*2.
C TRAILERS AND A HAULER ARE READY, HAUL TO GIN.
TRIP=TACRE*RTRIP
C IF AT THE START OF THIS TIME PERIOD, A HARV. IS FULL, IT IS ASSUME
C TO BE IDLE
P11=479.0/(GT0*13000.0)
HARTOL=P11*YA(IU )+PL(IU )*2.0*MATRTE(IU ,IDAL)
IF (HARTOL.GT.500) HARTOL=500.
IF (HAMT(J).GT.X0-HARTOL) GO TO 10
AIDT=AMT. IN HARVESTER DURING DELTA-T
AIDT=(1./TACRE)*0.1*VYA*LBH
C HAMT(J)=AMT. IN JTH HARV.
HAMT(J)=HAMT(J)+AIDT
TACS(IU )=TACS(IU )+ACDELT
TTACS=TTACS+ACDELT
COTT(IU )=COTT(IU )-AIDT
IF (COTT(IU ).LT.0.0) COTT(IU )=0.0
TCN=TCN+AIDT
C IF THE HARV. BASKET IS WITHIN HARTOL LBS
C OF CAPACITY, THEN IT IS
C DUMPED, OTHERWISE, LOOK FOR NEXT HARV.
IF (HAMT(J).LE.X0-HARTOL) GO TO A
C
10 CONTINUE
C LOOK AT TRAILERS TO SEE IF WE CAN DUMP HARV.
C CHECKS FOR EMPTY TRAILERS; IF ONE IS EMPTY, THE FLAG IS SET FOR
C FILLING IT
DO 11 K=1,NTLS
IF (IFLAG(K).EQ.1.AND.NSGN(K).EQ.J) GO TO 12
11 CONTINUE
DO 37 K=1,NTLS
IF (IFLAG(K).EQ.0) NSGN(K)=J
IF (IFLAG(K).EQ.0) IFLAG(K)=1
IF (IFLAG(K).EQ.1.AND.NSGN(K).EQ.J) WRITE(3,601)K,INT,IDAY,J
601 FORMAT(' ',TRAILER NO.,I3,2X,'IS SELECTED TO BE FILLED AT TIME',
1I4,2X,'OF DAY',I4,2X,'BY HARVESTER',I2)
IF (IFLAG(K).EQ.1.AND.NSGN(K).EQ.J) GO TO 12
37 CONTINUE
NSGN(K)=ASSIGNING THE KTH TRAILER TO THE JTH HARV.
IFLAG=0 MEANS TRAILER WAITING TO BE FILLED.
IFLAG=1 MEANS TRAILER IS BEING LOADED
IFLAG=2 MEANS TRAILER IS FULL
IFLAG=3 MEANS TRAILER IS IN TRANSIT TO GIN
IFLAG=4 MEANS TRAILER IS IN QUEUE
IFLAG=5 MEANS TRAILER EMPTY AND ON GIN YARD
IFLAG=6 MEANS TRAILER ON WAY HOME
IF DO LOOP COMPLETED, NO TRAILER AVAIL.
IFLAG(J)=0 LETS HARV DUMP
IFLAG(J)=1 MEANS IDLE HARV.
IFLAG(J)=1
IDL(J)=IDL(J)+0.1
GO TO B
C
C FILLING THE K+H TRAILER FROM THE J+H HARVESTER
12 TAMT(K)=TAMT(K)+HAMT(J)
IF (TAMT(K).GT.TCAP-500.) IFLAG(K)=2
IF (IFLAG(K).EQ.2) WRITE(3,602)K,INT
602 FORMAT(' ',TRAILER NO.,I4,2X,'WAS FILLED AT TIME',I4)
C CHECKS FOR FULL TRAILERS
WRITE(3,64)IDAY,INT,J,HAMT(J),K,TAMT(K),IHARV(J),IDL(J)
64 FORMAT(' ',6X,'DAY',I4,'TIME',I4,6X,'HARVESTER NO.',I2,'HAS',F8.1,
1'LBS. OF SEED COTTON' BEING DUMPED INTO TRAILER',I3,'/',' WHICH NOW
1HAS',F10.1,'LBS. OF SEED COTTON',10X,'FIELD NO.',I5,6X,'IDLE TIME=
1',F4.0)
C EMPTIES THE J+H HARV.
HAMT(J)=0.
IFLAG(J)=0
C CONTINUE
C
8018 TRD=0

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PROGRAM LISTING—Continued

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C   AFTER HARV. DURING DELTA T, THE TRAILERS ARE EXAMINED AND IF TWO
C   IF (IHLR.NE.0) GO TO 6
C   TO SEE IF ANY TRAILERS LEFT ON FARM; IF SO HE WILL HAUL 1 TRAILER
C   DO 13 IT=1,NTLS
C   IF (IQUIT.EQ.NHVS.AND.IFLAG(IT).EQ.2) IFLAG(IT)=3
C   IF (IFLAG(IT).EQ.3) GO TO 18
85  CONTINUE
C   TRD=0
C   DO 17 IT=1,NTLS
C   TRDK=0
C   IF (IFLAG(IT).EQ.2) TRDK=1
17  TRD=TRD+TRDK
C   KIT=0
C   DO 112 IT=1,NTLS
C   KI=0
C   IF (TRD.LT.2) GO TO 6
C   IF (IFLAG(IT).EQ.2) KT=1
C   KIT=KIT+KT
C   IF (KI.EQ.1) IFLAG(IT)=3
C   IF (IFLAG(IT).EQ.3) WRITE(3,603) IT,TD
603  FORMAT(' ', 'TRAILER NO.', I4, 2X, 'LEAVES FOR GIN AT TIME', I4)
C   IF (KIT.EQ.1) GO TO 18
112 CONTINUE
C   GO TO 6
C   IHLR IS THE PICK-UP DRIVER
C   IHLR=0, HE IS ON FARM
C   IHLR=1, HE IS ON WAY TO GIN
C   IHLR=2, HE IS AT GIN
C   IHLR=3, HE IS ON WAY TO FARM
16  IHLR=1
C   NHAUL=NHAUL+1
C   TRD=(XMT/15.)*10.
C   ENQ=IDT+TRD+2
C   TLNQ=TIDT+TRD+2
C   DO 23 JK=1,NTLS
C   IF (IFLAG(JK).NE.3) GO TO 23
C   ENT(JK)=TLNQ
23  CONTINUE
C
C   GINNING PORTION OF PROGRAM
C   b CONTINUE
C   IZ=0
C   ARPH=0.
C   IF (IDT.GT.IHSTRT.AND.IDT.LT.IHEND) ARPH=(AR/(IHEND-IHSTRT))*10.
C   TNBLS=TNBLS+ARPH/10.
C
C   TNBLS=TOTAL NO. OF BALES ARRIVED AT GIN, ACCUMULATED
C   THIS LOOP CHECKS FOR TRAILERS ARRIVING DURING THIS DELTA-T
C   DO 27 JL=1,NTLS
C   IF (TIDT.LT.ENT(JL).OR.IFLAG(JL).NE.3) GO TO 27
C   IF (IHLR.EQ.1) IHLR=2
C   IF (IHLR.NE.2) GO TO 27
C   IRT=TIDT+2
C   ITRN=IRT+(XMT/15.)*10.
C   IF (IFLAG(JL).EQ.3) GO TO 29
C   ION=TIME THE I+H TRAILER ENTERS THE GIN QUEUE
C   TNBLS=TNBLS+TCAP*(GTO/47000.)
C   GO TO 27
29  IFLAG(JL)=4
C   IZ=IZ+1
C   ION(JL)=BKLG-X(1)*ARPH*0.1+BGND+(TCAP*GTO/47000.0)
C   IF (IZ.EQ.2) ION(JL)=BKLG-PNX*ARPH*0.1+2.0*(TCAP*GTO/47000.0)+BGND
C   WRITE(3,71) JL, IDT, IDAY, BKLK
71  FORMAT(' ', 'TRAILER NO.', I4, 2X, 'ENTERS GIN QUEUE AT TIME', I4, 2X, '
1 OF DAY', I4, ' ', 'GIN BACKLOG IS', F9.1, 2X, 'BALES')
C   27 CONTINUE
C
C   IF (TIDT.EQ.IRTN.AND.IHLR.EQ.2) IHLR=0
C   IF (IGFLG.EQ.1) GO TO 998
C   IF (TIDT.LT.GOP) GO TO 999
C   IF (BGND.GE.TNRLS-0.7) GO TO 997
C   CALCULATES GIN FAILURE TIMES AND DOWN TIMES, SETS GOP FOR WHEN
C   GIN IS FIXED AND STARTS TO OPERATE AGAIN
C   RU=1.-EXP(-0.1/12.)
C   Y(1)=X(1)*8192.*16384.
C   CALL RANDU(X,NN)
C   PNK=X(1)

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PROGRAM LISTING—Continued

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      IF(RNX.GT.KO) GOTO 30
C     GIN BREAKS DOWN IF RNX LESS THAN PROB. OF FAILURE
      SUX=0.
      DO 1001 IR=1,4
      X(1)=X(1)*.8192.*16384.
1001  CALL RANDU(X,NN)
      SUX=SUX+X(1)
      RNX=X(1)
C     WITH 10 HEKE, IT MEANS 1 HR. AVERAGE REPAIR TIME
      GDT=10.*ALOG(1.-RNX)
      GOP=TIDT+ABS(GDT)
      WRITE(3,604) IDT, IDAY, GOT
604  FORMAT(' ', 'GIN BREAKS DOWN AT TIME', I4, 2X, 'OF DAY', I4, 2X, 'REPAIR
      TIME IS', F6.1, 2X, 'TIME INCREMENTS')
C     ONLY WHEN TIDT IS GREATER THAN GOP DOES GIN BEGIN TO OPERATE AGAIN
      30 CONTINUE
C
C     RANDOMLY COMPUTES AMT GINNED DURING AT
      SGRT=0.6
      CALL GAUSS(X, NN, SGRT, GRTE, GAMT)
      GAMT=GAMT*.1
      IF(BKLG.LT.0.1) GO TO 996
      IF(GAMT.GT.BKLG) GAMT=BKLG
      DGIN=DGIN+GAMT
      BGND=BGND+GAMT
996  BKLG=TNRLS-BGND
997  CONTINUE
      IMPT=0
C
C     IMPT=NO. TRAILERS READY TO BE HAULED BACK TO FARM. MAY. OF 2
      CHECKS FOR TRAILERS BEING GINNED AND RETURNED TO FARM
      DO 282 I=1, NTLS
      IF(IFLAG(I).NE.4) GO TO 282
      IF(IGN(I).GT.BGND) GO TO 282
      IFLAG(I)=5
      TMT(I)=0.
      WRITE(3,605) I, IDT
605  FORMAT(' ', 'TRAILER NO.', I4, 2X, 'IS GINNED. TIME IS', I4)
282  IF(IFLAG(I).EQ.5) IMPT=IMPT+1
      ICNT=0
      DO 40 I=1, NTLS
      IF(IFLAG(I).NE.5) GO TO 41
      IF(IHLR.EQ.1.OR.IHLR.EQ.3) GO TO 41
      IF(IHLR.EQ.0.AND.IMPT.EQ.1) GO TO 41
      IF(IDT.GT.80) GO TO 40
      ICNT=ICNT+1
      RT(I)=TIDT+(XMI/15.)*10.
      IF(IHLR.EQ.0) RT(I)=TIDT+((XMI/15.)*10.)*2.
      IF(ICNT.EQ.2.OR.IHLR.EQ.2) IHLR=3
      IF(ICNT.EQ.2) NHAUL=NHAUL+1
      IFLAG(I)=6
41  IF(TIDT.GT.RT(I).AND.IFLAG(I).EQ.6) GO TO 111
      GO TO 40
111  IFLAG(I)=0
      WRITE(3,114) I, IDT, IDAY
114  FORMAT(' ', 'TRAILER NO.', I4, 2X, 'RETURNS TO FARM AT TIME', I4, 2X,
      'OF DAY', I4)
      IHLR=0
40  CONTINUE
998  CONTINUE
      IF(IDT.LT.1GT) GO TO 20
      TW=1GT/10
      WRITE(3,606)
606  FORMAT('0', //, ' ', 32X, 'DAILY GIN SUMMARY')
      WRITE(3,607)
607  FORMAT('0', 1X, 'DAY NO. NO. ARRIVALS BALES GINNED TOTAL BALES
      1 TOTAL BALES CURRENT OPERATING', //, ' ', 12X, 'BALES', 10X, 'TODAY',
      17X, 'RECEIVED', 7X, 'GINNED', 5X, 'BACKLOG', 3X, 'HOURS TODAY' //)
      WRITE(3,608) IDAY, AR, DGIN, TNRLS, BGND, BKLG, IDT
608  FORMAT(' ', I6, F12.1, F13.1, F12.0, 8X, F8.0, F11.1, 8X, I3, //)
      IF(IDAY.GT.410.AND.BKLG.LT.2) GO TO 7
      IF(TTACS.GE.ACST) GO TO 999
      WRITE(3,733)
733  FORMAT('0', 6X, 'DAILY HARVESTING SUMMARY')
      WRITE(3,615)
615  FORMAT('0', 4X, 'HOURS', 6X, 'TOTAL ACRES TOTAL COTTON HARVESTER',
      15X, 'WHICH HARVEST',
      17X, 'OPERATION HARVESTED HARVESTED IDLE TIME')
      DO 612 IH=1, NHVS

```

PROGRAM LISTING—Continued

```

612 WRITE(3,613) IH,TTACS,TCN,IDL(IH),INOTIM
613 FORMAT('0',2X,I2,2X,'6',7X,F7.2,7X,F9.1,9X,F5.1,11X,I2,/)
999 CONTINUE
7 CONTINUE
CTLS = COST PER TRAILER PER YEAR
CTR = TOTAL COST OF TRAILERS PER YEAR
NHAUL = NUMBER OF TRIPS HAULER MAKES TO THE GIN
CHL = COST PER MILE TO OPERATE PICKUP HAULING, NOT COUNTING LABOR
CHAUL = TOTAL YEARLY COST FOR HAULING TO GIN
NTH = TOTAL NO. OF DAYS HARVESTING, INCLUDING RAINY DAYS
CFLBR = TOTAL COST OF FARM LABOR FOR YEAR
CGLBR = COST OF GIN LABOR FOR UNLOADING SYSTEM AT GIN
NGLBR = NO. OF LABORERS FOR THIS GIN UNLOADING SYSTEM
GCPB = GIN COST PER BALE, FROM SMITH UPDATED STUDY
VOL = GIN SEASONAL VOLUME
HPPH = HOURS RUN PER HARVESTER
ASSUME 3 GAL PER HR AT .33 PER GAL.
CTAX = TAXES/YR.
CLUB = LUR. COSTS/YEAR
CINS = INSURANCE COST
CINT = INTEREST COST
CDEP = DEPRECIATION COST
CHARV = TOTAL COST OF HARVESTING FOR YEAR
CGIN = TOTAL GIN COST FOR YEAR
TCPB = TOTAL COST PER BALE
CLOS = YLOS*CCOT*GTO/100.
CTR = NTLS*CTLS
CHAUL = NHAUL*CHL*XM1*2.
NTH = 1+NOH-NSH-(NOH-NSH)/7
CFLBR = (CLBR*8.*NTH)*(NHVS+2+NHVS/3)
CGLBR = (CLBR*TIOT/10.)*NGLBR
GCPB = 15.98+(24028.65+2547.29*GRTE)/RGND
HPPH = (1.0/(ACDELT*10.0))*ACST/NHVS
CFUEL = HPPH*0.99
CLUB = 0.15*CFUEL
CTAX = 0.01*HARC
CINS = 0.005*HARC
CINT = ((HARC+SV)/2.)*0.07
CDEP = (HARC-SV)/LIFE
CREP = 0.01*HARC
CHARV = CFUEL+CLUB+CTAX+CINS+CINT+CDEP+CREP
CHARV = CHARV*NHVS
RLLS = TCN*(GTO/100.)/479.
CGIN = GCPB*BLLS
TCPB = GCPB+(CHARV+CTR+CHAUL+CFLBR+CLOS)/RLLS
WRITE (6,635)
DO 634 IC=1,NTLS
TI(IC)=TT(IC)-TE(IC)
634 WRITE(3,633) IC,TE(IC),TT(IC)
635 FORMAT('0',10X,'TRAILER UTILIZATION',//,4X,'TRAILER',6X,'EMPTY',
16X,'FULL')
633 FORMAT(' ',7X,I3,7X,F6.1,5X,F9.1)
WRITE(3,1080) BLLS,HPPH,NTH,CLOS
1080 FORMAT(' ',BALES HARVESTED-',F6.1,/,/,', 'HOURS OPERATION PER HAR
1VESTER-',F7.2,/,/,', 'DAYS LABOR CHARGED FOR HARVESTING',I5,/,/,',
2,'LOST COTTON COST-',F8.2)
WRITE (6,502) IYR, CHAUL, CFLAR, CHARV, CGIN, TCPB
502 FORMAT('0',10X,'YEAR-NO',I2,/,',HHAULING COST',8X,
1F6.2,/,',FFARM LABOR COST',5X,FA.2,/,',HHARVESTER COST',5X,
1F9.2,/,',GGINNING COST',8X,FA.2,/,',1X,28(1H*)',/,',TTOTAL
1COST PER BALE IS',F6.2,','FOR HARVESTING, HAULING, AND GINNING',
1F6.2,2X,'BALES')
IF(IYR.LT.NYR)GO TO 1000
STOP
END

```

```

SUBROUTINE SELECT(N,M,X,NN,PSTART,MASTRT,MATRTF)
DIMENSION MATRTE(50,50)
MSG=GIN STARTING DATE
NSH=HARVESTING STARTING DATE
XN=AVG. GIN STARTING DATE
XM=AVG. FIRST HARV. DATE
SN AND SM ARE MEASURES OF VARIATION
XN=287.
XM=308.

```

PROGRAM LISTING—Continued

```

SN=3.
CALL GAUSS(X,NN,SN,XN,G)
N=G
DO 11=1,50
IF(MATRIE(1,1).LT.PSTART)GO TO 1
M=MASTRT+1+1
GO TO 2
1 CONTINUE
2 RETURN
END

```

```

SUBROUTINE DELAYH(X,NN,R,IDAY,ISTART,IRAIN,RFIN)
C DIMENSION RFIN(400),X(1)
R=RAINFALL, INCHES
IF(IRAIN.EQ.1) GO TO 20
CALL RAIN(R,X,NN)
GO TO 30
20 R=RFIN(IDAY)
30 CONTINUE
XK1=0.6
SK1=0.15
XK2=1.00
SK2=0.20
XK3=2.00
SK3=0.40
C THE PREC. VARIABLES DESCRIBE A DELAY STEP FUNCTION WHERE STEP
C BREAK POINTS ARE RANDOMLY CHOSEN
IF(R.LT.0.01) GO TO 71
CALL GAUSS(X,NN,SR1,XR1,DLMT1)
CALL GAUSS(X,NN,SR2,XR2,DLMT2)
IF(R.LT.DLMT1)DLAY=3.
IF(R.GT.DLMT1,AND,R.LT.DLMT2)DLAY=4.
72 IF(R.GT.DLMT2)DLAY=5.
DLAY=DLAY+0.1
IF(ISTART.GT.IDAY)ISTART=ISTART+IDLAY
ISTART=IDAY+IDLAY
IF(ISTART-IDAY.GT.4)ISTART=IDAY+4
C A MAX DELAY OF 4 DAYS FROM CURRENT DAY
IF(R.GE.0.01)WRITE(3,61)IDAY,R,ISTART
61 FORMAT('0','DAY NO.='I4,4X,'RAIN='F5.2,4X,'DELAY UNTIL DAY='I4)
71 CONTINUE
RETURN
END

```

```

SUBROUTINE RAIN(R,X,NN)
DIMENSION X(1)
R=0.
RETURN
END

```

```

SUBROUTINE ARR(R,X,NN,AR,NDAY,IG,VOL,IAR,SA,NA,NB,NC,IARFLG)
REAL NA,NB,NC
DIMENSION X(1)
IG=0
DATA NBLNK/0/,NSTART/0/
IF(NDAY.LT.NSTART) IG=1
IF(NDAY.LT.NSTART)GO TO 1
IF(R.GT.0)GO TO 2
IF(IAR.GT.0) GO TO 1
XA=NDAY-NBLNK
IF(IARFLG.EQ.1) GO TO 10
SA=148.456/((VOL)**0.4426)
SA=3.37
NA=0.0027*VOL-3.52-6.0
NB=100./SA+0.67*NA-2.67
NC=NB+8.
10 FOX=((XA/NA)**2)*SA

```

PROGRAM LISTING—Continued

```

IF (YA.GT.NA) FOX=SA
IF (XA.GT.NB) FOX=((C-XA)/B.)**2)*SA
IF (XA.GT.NC) FOX=0.
AAR=FOX*VOL/100.
AR SIG=AAR/2.5
CALL GAUSS(X,NN,AR SIG,AAR,AR)
IF (AR.LT.0.) AR=0.
GO TO 3
2  N=1.5*X(1)
   IG=NN
   NSTART=NDAY+N
1  NDLNK=NRLNK+1
   AR=0
3  RETURN
   END

```

```

50  SUBROUTINE GAUSS(X,NN,S,AM,Y)
    DIMENSION X(1)
    A=0.0
    DO 50 I=1,12
      X(1)=X(1)*8192.*16384.
      CALL RANDU(X,NN)
      Y=X(1)
      A=A+Y
      Y=(A-6.0)*S+AM
    RETURN
    END

```

```

SUBROUTINE RANDU(X,N)
DIMENSION X(1)
K=316227
NK=N*K
RN=0
R=RN/34359738367.
X(1)=ABS(R)
N=NK
RETURN
END

```


EXAMPLE RUN

Input Data

1	1	14	6	1	2.5	18.5	1.60	12.0	0.10
25.10		0.93		200.00					
20.00		1.00		400.00					
5.00		1.40		250.00					
12.50		1.20		75.00					
51.10		1.00		250.00					
30.00		1.00		400.00					

305

0.000.000.080.080.100.100.100.100.100.200.200.200.250.250.300.300.300.300.350.40
0.400.400.500.500.500.600.650.700.700.700.800.800.800.800.900.900.900.900.900.90
0.950.950.950.951.001.001.001.001.001.000.000.000.000.000.000.000.000.000.000.00
0.200.300.400.400.400.400.400.400.400.500.500.500.500.500.500.500.500.500.500.50
0.900.900.950.951.001.001.001.001.001.001.001.001.001.001.001.001.001.001.001.00
0.000.000.080.080.100.100.100.100.100.200.200.200.250.250.300.300.300.300.350.40
0.400.400.500.500.500.600.650.700.700.700.800.800.800.800.900.900.900.900.900.90
0.950.950.950.951.001.001.001.001.001.000.000.000.000.000.000.000.000.000.000.00
0.200.300.400.400.400.400.400.400.400.500.500.500.500.500.500.500.500.500.500.50
0.900.900.950.951.001.001.001.001.001.001.001.001.001.001.001.001.001.001.001.00
0.000.000.080.080.100.100.100.100.100.200.200.200.250.250.300.300.300.300.350.40
0.400.400.500.500.500.600.650.700.700.700.800.800.800.800.900.900.900.900.900.90
0.950.950.950.951.001.001.001.001.001.000.000.000.000.000.000.000.000.000.000.00
0.200.300.400.400.400.400.400.400.400.500.500.500.500.500.500.500.500.500.500.50
0.900.900.950.951.001.001.001.001.001.001.001.001.001.001.001.001.001.001.001.00

108.30	0.059	7149.00	13175.00	3000.00	8	1584.00
3.0	0.28	5.0	3.37	12	34	42
1						1
322	.22	327	.15	335	.02	336
350	.04	363	.01	337	.47	340
0.002	40	100		343	.36	344
1	314	333	4		.01	
			0.800		.02	

Output Data

HARVEST-GIN FOR N.C. STATE EXAMPLE

NO.HARV.	NO.TRAILERS	TRAILER CAP.	DIST.TO GIN
1	14	7767.6	2.5

FIELD	ACRES	YIELD	ROW LENGTH
1	25.10	.93	200.00
2	20.00	1.00	400.00
3	5.00	1.40	250.00
4	12.50	1.20	75.00
5	51.10	1.00	250.00
6	30.00	1.00	400.00

GIN STARTING DAY IS 314

HARV. STARTING DAY IS 333

TOTAL COTTON TO HARVEST IS 379168.6POUNDS

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
1 6	.00	.0	.0	1

GIN BREAKS DOWN AT TIME 87 OF DAY 319 REPAIR TIME IS -4.2 TIME INCREMENTS

DAILY GIN SUMMARY

DAY NO.	NO.ARRIVALS BALES	BALES GINNED TODAY	TOTAL BALES RECEIVED	TOTAL BALES GINNED	CURRENT BACKLOG	OPERATING HOURS TODAY
319	38.1	37.4	90.	90.	.6	11

Output Data—Continued

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
1 6	.00	.0	.0	1

DAILY GIN SUMMARY

DAY NO.	NO. ARRIVALS BALES	BALES GINNED TODAY	TOTAL BALES RECEIVED	TOTAL BALES GINNED	CURRENT BACKLOG	OPERATING HOURS TODAY
320	39.9	39.2	130.	129.	.7	11

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
1 6	.00	.0	.0	1

DAILY GIN SUMMARY

DAY NO.	NO. ARRIVALS BALES	BALES GINNED TODAY	TOTAL BALES RECEIVED	TOTAL BALES GINNED	CURRENT BACKLOG	OPERATING HOURS TODAY
321	84.6	69.4	213.	198.	14.4	11

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
1 6	.00	.0	.0	1

DAILY GIN SUMMARY

DAY NO.	NO. ARRIVALS BALES	BALES GINNED TODAY	TOTAL BALES RECEIVED	TOTAL BALES GINNED	CURRENT BACKLOG	OPERATING HOURS TODAY
333	247.5	357.9	847	847.	.0	23

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
1 6	5.98	10148.9	.0	1

TRAILER NO. 2 IS SELECTED TO BE FILLED AT TIME 43 OF DAY 334 BY HARVESTER 1
 DAY 334 TIME 43 HARVESTER NO. 1 HAS 2075.1 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 2075.1 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 HARVESTER NO. 1 BREAKS DOWN TIME 47 OF DAY 334 REPAIR TIME IS -1.9 TIME INCREMENTS
 HARVESTER NO. 1 BREAKS DOWN TIME 48 OF DAY 334 REPAIR TIME IS -10.0 TIME INCREMENTS
 DAY 334 TIME 57 HARVESTER NO. 1 HAS 2227.3 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 4302.5 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 DAY 334 TIME 59.1 HARVESTER NO. 1 HAS 2227.3 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 4302.5 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 DAY 334 TIME 64 HARVESTER NO. 1 HAS 2197.5 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 6500.0 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 TRAILER NO. 2 WAS FILLED AT TIME 71
 DAY 334 TIME 71 HARVESTER NO. 1 HAS 2305.1 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 8805.1 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 TRAILER NO. 1 LEAVES FOR GIN AT TIME 71 OF DAY 334. GIN BACKLOG IS 6.5 BALES
 TRAILER NO. 1 ENTERS GIN QUEUE AT TIME 75 OF DAY 334 BY HARVESTER 1
 TRAILER NO. 3 IS SELECTED TO BE FILLED AT TIME 77 OF DAY 334 BY HARVESTER 1
 DAY 334 TIME 77 HARVESTER NO. 1 HAS 2098.0 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 2098.0 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 TRAILER NO. 1 IS GINNED. TIME IS 78
 DAY 334 TIME 84 HARVESTER NO. 1 HAS 2406.7 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 4504.7 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 DAY 334 TIME 90 HARVESTER NO. 1 HAS 2074.4 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 6579.2 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 TRAILER NO. 3 WAS FILLED AT TIME 97
 DAY 334 TIME 97 HARVESTER NO. 1 HAS 2387.5 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 8966.7 LBS. OF SEED COTTON FIELD NO. 1 IDLE TIME= 0.
 TRAILER NO. 2 LEAVES FOR GIN AT TIME 97 OF DAY 334. GIN BACKLOG IS 9.1 BALES
 TRAILER NO. 2 ENTERS GIN QUEUE AT TIME 101

Output Data—Continued

DAILY GIN SUMMARY

DAY NO.	NO. ARRIVALS BALES	BALES GINNED TODAY	TOTAL BALES RECEIVED	TOTAL BALES GINNED	CURRENT BACKLOG	OPERATING HOURS TODAY
334	110.3	102.0	956.	955.	.5	11

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
1 6	16.72	27889.5	.0	1

YLOS= .00

DAILY GIN SUMMARY

DAY NO.	NO. ARRIVALS BALES	BALES GINNED TODAY	TOTAL BALES RECEIVED	TOTAL BALES GINNED	CURRENT BACKLOG	OPERATING HOURS TODAY
360	180.5	361.9	3010.	3000.	10.3	23

DAILY HARVESTING SUMMARY

HOURS OPERATION	TOTAL ACRES HARVESTED	TOTAL COTTON HARVESTED	HARVESTER IDLE TIME	WHICH HARVEST
6	102.17	269287.1	.0	1

YLOS= 3641.90

TRAILER NO. 1 RETURNS TO FARM AT TIME 5 OF DAY 361
 TRAILER NO. 2 RETURNS TO FARM AT TIME 5 OF DAY 361
 TRAILER NO. 4 RETURNS TO FARM AT TIME 9 OF DAY 361
 TRAILER NO. 5 RETURNS TO FARM AT TIME 9 OF DAY 361
 TRAILER NO. 3 IS GINNED. TIME IS 43
 TRAILER NO. 1 IS SELECTED TO BE FILLED AT TIME 44 OF DAY 361 BY HARVESTER 1
 DAY 361 TIME 44 HARVESTER NO. 1 HAS 2399.6 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 1
 WHICH NOW HAS 2399.6 LBS. OF SEED COTTON FIELD NO. 5 IDLE TIME= 0.
 DAY 361 TIME 48 HARVESTER NO. 1 HAS 2262.3 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 1
 WHICH NOW HAS 4661.9 LBS. OF SEED COTTON FIELD NO. 5 IDLE TIME= 0.
 DAY 361 TIME 52 HARVESTER NO. 1 HAS 2179.6 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 1
 WHICH NOW HAS 6841.5 LBS. OF SEED COTTON FIELD NO. 5 IDLE TIME= 0.
 TRAILER NO. 1 WAS FILLED AT TIME 57
 DAY 361 TIME 57 HARVESTER NO. 1 HAS 2567.5 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 1
 WHICH NOW HAS 9409.0 LBS. OF SEED COTTON FIELD NO. 5 IDLE TIME= 0.
 TRAILER NO. 1 LEAVES FOR GIN AT TIME 57
 HARVESTER NO. 1 BREAKS DOWN. TIME 60 OF DAY 361 REPAIR TIME IS -3.3 TIME INCREMENTS
 893.0 392.2 98.7 .546 A.B.C. EFF
 TRAILER NO. 1 ENTERS GIN QUEUE AT TIME 61 OF DAY 361. GIN BACKLOG IS 81.0 BALES
 TRAILER NO. 3 RETURNS TO FARM AT TIME 63 OF DAY 361
 TRAILER NO. 2 IS SELECTED TO BE FILLED AT TIME 64 OF DAY 361 BY HARVESTER 1
 DAY 361 TIME 64 HARVESTER NO. 1 HAS 2356.2 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 2356.2 LBS. OF SEED COTTON FIELD NO. 5 IDLE TIME= 0.
 DAY 361 TIME 68 HARVESTER NO. 1 HAS 2112.0 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 4468.2 LBS. OF SEED COTTON FIELD NO. 5 IDLE TIME= 0.
 COMPLETED HARVESTING FIELD NO. 5 ON DAY 361 THIS FIELD HAS BEEN HARVESTED 1 TIME
 REMAINING COTTON IS 1573.

YA .01189

DAY 361 TIME 72 HARVESTER NO. 1 HAS 2418.6 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 6886.8 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.
 TRAILER NO. 2 WAS FILLED AT TIME 76
 DAY 361 TIME 76 HARVESTER NO. 1 HAS 2382.9 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 2
 WHICH NOW HAS 9269.7 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.
 TRAILER NO. 2 LEAVES FOR GIN AT TIME 76
 TRAILER NO. 3 IS SELECTED TO BE FILLED AT TIME 80 OF DAY 361 BY HARVESTER 1
 DAY 361 TIME 80 HARVESTER NO. 1 HAS 2389.8 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 2389.8 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.
 TRAILER NO. 2 ENTERS GIN QUEUE AT TIME 80 OF DAY 361. GIN BACKLOG IS 156.4 BALES
 DAY 361 TIME 84 HARVESTER NO. 1 HAS 2334.3 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 4724.1 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.
 DAY 361 TIME 88 HARVESTER NO. 1 HAS 2320.7 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 7044.9 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.

Output Data—Continued

TRAILER NO. 3 WAS FILLED AT TIME 92
 DAY 361 TIME 92 HARVESTER NO. 1 HAS 2480.9 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 3
 WHICH NOW HAS 9525.8 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.
 TRAILER NO. 3 LEAVES FOR GIN AT TIME 92
 GIN BREAKS DOWN AT TIME 92 OF DAY 361 REPAIR TIME IS -11.0 TIME INCREMENTS
 TRAILER NO. 4 IS SELECTED TO BE FILLED AT TIME 96 OF DAY 361 BY HARVESTER 1
 DAY 361 TIME 96 HARVESTER NO. 1 HAS 2634.2 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 4
 WHICH NOW HAS 2634.2 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.
 TRAILER NO. 3 ENTERS GIN QUEUE AT TIME 96 OF DAY 361. GIN BACKLOG IS 208.2 BALES
 DAY 361 TIME 100 HARVESTER NO. 1 HAS 2572.8 LBS. OF SEED COTTON BEING DUMPED INTO TRAILER 4
 WHICH NOW HAS 5207.1 LBS. OF SEED COTTON FIELD NO. 6 IDLE TIME= 0.

TRAILER UTILIZATION

TRAILER	EMPTY	FULL
1	21.0	55.2
2	34.7	41.5
3	44.2	32.0
4	50.7	25.5
5	28.9	47.3
6	57.6	18.6
7	69.5	6.7
8	71.1	5.1
9	76.2	.0
10	76.2	.0
11	76.2	.0
12	76.2	.0
13	76.2	.0
14	76.2	.0

BALES HARVESTED- 140.0

HOURS OPERATION PER HARVESTER- 59.58

DAYS LABOR CHARGED FOR HARVESTING 31

HARVESTER COST 2225.20

GINNING COST 3456.99

TOTAL COST PER BALE IS 61.77 FOR HARVESTING , HAULING , AND GINNING

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